INSTRUMENTS AND CONTROL SYSTEMS

APRIL 1960

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THIS PRINTING: 37,000

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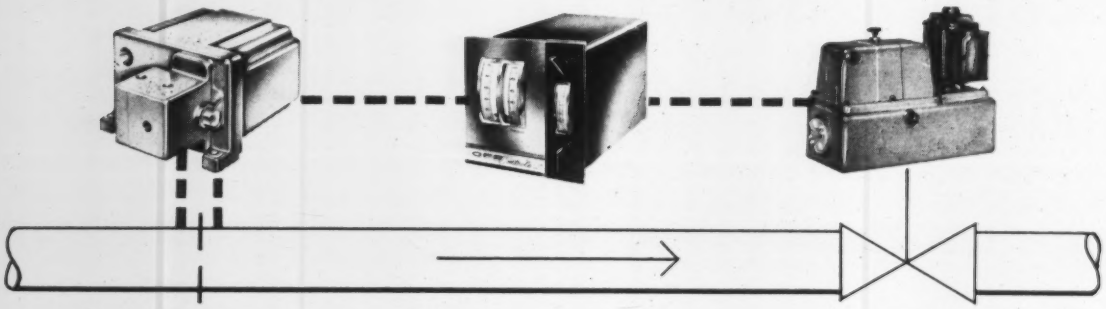

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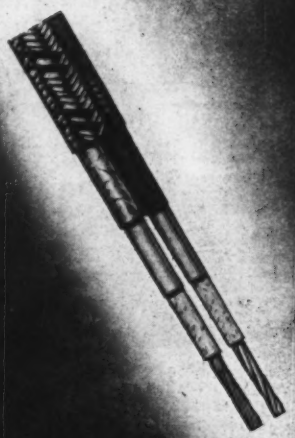

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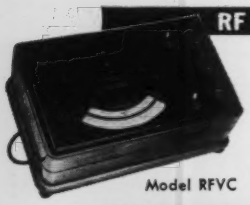
NEW INSTRUMENTS *by Sensitive Research*

RF VOLTMETER CALIBRATOR

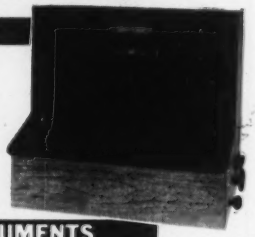


Model RFVC

Model RFVC — Radio Frequency Self Checking RMS voltmeter for the certification of VTVM's from DC to 10 Mc. Accuracy .3% of full scale ± .2% frequency influence. Ranges .01/.1/1/3 V. Checks its own accuracy against a .05% stable internal standard source.

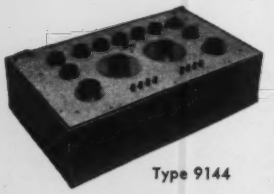
CALIBRATION CONSOLES

Model LTC — AC-DC/DC. Accuracy .05% of actual reading. Ranges .5 V. to 1111 V.; 1 Ma (2 Ma on AC) to 11.11 amps. Resolution .01%. Frequency range DC to 25 KC. Direct % Error Readout. Model LT-PS — AC power supply to full capabilities of console. Harmonic distortion less than .1%. Other consoles available.



Model LTC

DC POTENTIOMETERS



Type 9144

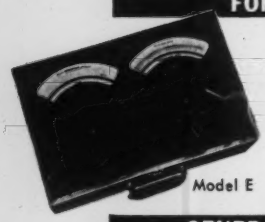
A new line of 6 figure instruments guaranteed 10X more accurate than any potentiometer commercially available today, having a subdivision of 1 part in 10^6 of the 1 volt setting and calibrated to be usable to an accuracy of ± .0002% or better. Absolute accuracy guaranteed to ± .001% nominal or better. Resolution excellent for comparison of saturated standard cells. Temperature controlled. High sensitivity Galvanometer, 4 terminal NBS Type resistors, ratio boxes and other primary standards available.

EXPANDED SCALE INSTRUMENTS

Model INCRE — Differential incremeter. A NEW .05% f.s. accurate expanded scale DC standard for rack panel mounting or portable use. Combines the high comparison accuracy of the differential instrument with a .005% stable source. Scale has an effective length of 63" or 70", and a resolution of 1000 divisions. Each 10% of any range is expanded over the instrument's actual 6.3" or 7" scale length. Direct reading. No balancing or nulling. Single or multi-range combinations from 200 ua. to 30 amps. and 200 mv. to 1 kv.

Model INCRE

FORM FACTOR INSTRUMENT

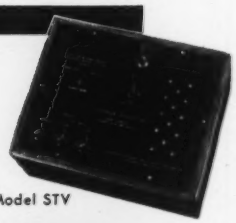


Model E

Model E — supplies a direct reading correction factor for instruments affected by non-sinusoidal wave form deviation. Indicates ratio of true RMS values to average, positive peak, and negative peak values. Determines the true RMS values of average and peak reading instruments that are used on a distorted wave. Accuracy: .2% between 25-500 cps.

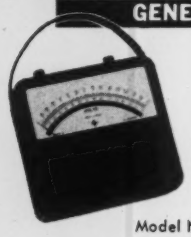
DC VOLTAGE STANDARDS

Model STV — Nominal output 1.0000 V. and 1.0185 V. Accuracy ± .01%. Actual output certified within ± .001% and guaranteed stable within ± .005%. 115 V. 60 cps input. Unaffected by extremes of temperature, short circuiting, and vibration. Replaces the standard cell. OEM types available.



Model STV

GENERAL PURPOSE PORTABLES



Model N

Model N—economically priced, stable and rugged .5% accurate DC current and voltage instrument. Long 6.1" scale. Employs a shielded "U" shaped magnet and not the common center core type characteristic of instruments in its price range. Model NP is for panel mounting. Model NSI is an AC version. All have molded bakelite cases and are available switch controlled.

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Model 2 AP — AC-DC Polyranger. Thermocouple type. Automatically protected for overloads of at least 5000%. Accuracy: .75%. Ranges from 2 ma. to 1 amp. and 2 V. to 500 V. Sensitivity: 500 ohms/V. Diamond Pivoted. Other Polyrangers with as many as 88 ranges available.

Model 2AP

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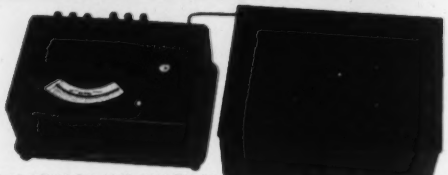

Model THACH AND THACH-PS

Model THACH — AC/DC Self Checking Volt-Amp Milliammeter. Accuracy ± .2% f.s. to 4 kc. Ranges — 10/20/50/100/200/500 ma.; 1/2/5 Amps; 1/2/5/10/20/50/100/200/500/1000 V. f.s. Checks its own accuracy against an internal standard cell. Model THACH-PS — special regulated THACH Power Supply (optional) automatically shuts off power to the THACH when switching ranges, reducing possibility of accidental overloads. Output is DC or 60 cps. (50-2500 cps. can be plugged in). Combination serves as a calibrator, measuring instrument, and general purpose power supply.

Primary and secondary standards for the accurate measurement or certification of AC-DC current, voltage, power, power factor, frequency and magnetic quantities. All electrical indicating instruments have hand-drawn mirrored scales and most are Diamond Pivoted, of course!
Not illustrated above, but available, are a complete line of portable and panel types including: • Wattmeters • Electrostatic Voltmeters • Peak Voltmeters • Thermocouple Instruments • Differentials • Ratiometers • Corrosion Instruments • Panel Instruments • Test Sets • Fluxmeters and accessories such as Shunts and Multipliers. All SRIC instruments have their certification directly traceable to the National Bureau of Standards and are unconditionally guaranteed.

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NUMBER 4

APRIL
1960

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from
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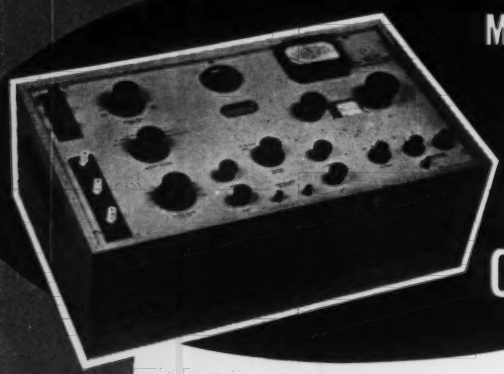

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I&CS LETTERS TO THE EDITOR

Editor, I&CS:

I am pleased that *INSTRUMENTS AND CONTROL SYSTEMS* is emphasizing basic standards of measurement and calibration in 1960. I feel that more emphasis should be placed on that aspect of our science than has been in the past.

A. G. McNish
Optics and Metrology Division
Nat'l Bureau of Standards
Washington, D. C.

Editor, I&CS:

I would like to add my voice to other opinions I have heard expressed, and commend you and your staff for putting out such an excellent publication during the past year. I think if we had to define this period, we would certainly have to call it the "Era of Certification and Standardization," and your magazine has done a better job in this field than all of the trade journals put together. I think if you can ever find it within you to settle down on one name, you will discover that you now have probably the most well read instrument magazine being published.

Marvin I. Steinberg
Vice President
Sensitive Research Instrument Corp.
New Rochelle, N. Y.

Editor, I&CS:

Some of your readers may be interested in a new Automotive Technology Laboratory that we are planning, which will include a "Bureau of Automotive Standards" for testing and evaluating cars, components, accessories and various products, including anti-smog devices. One of our objectives is to develop improved instrumentation, or adapt existing items, for these purposes and to pioneer their utilization in the world's largest automotive market, Los Angeles County.

We have in mind such items as a direct-reading miles-per-gallon meter, an improved (electric) chassis dynamometer, and a recording multi-cylinder pressure/vacuum transducer. Our thesis is that the fruits of modern space-age technology could be exploited much more effectively than they are at present for automotive diagnosis, measure

ment of performance and/or condition, and preventive maintenance. The medical profession, in the physiological repair and maintenance business, does a better job in this respect.

Perhaps your readers would be good enough to suggest a few interesting and appropriate projects, or available items, for our new Laboratory. We would welcome and appreciate such suggestions.

W. Julian King,
Sterling Automotive Eng., Inc.
2109 *Sawtelle Blvd.*
West Los Angeles 25, *Calif.*

Editor, I&CS:

One article on a sheet, as proposed by L. E. Johnson (Letters, Dec., '59), is a good thing.

Samuel A. Scharff
Consulting Engineer
New York, N. Y.

Editor, I&CS:

We would like to have a copy of your "Report on Public High-School Course in Modern Engineering Physics."

Joseph L. Dye, Director
Adult and Industrial Education
Anderson Public Schools
Anderson, Indiana

Editor, I&CS:

I would like to receive a reprint of an article appearing in the February 1959 issue of your magazine entitled "Report on Public High School Course in Modern Engineering Physics."

H. Schenzel
Chemical Engineer
Process Development
Refined Syrups & Sugars, Inc.
Yonkers, New York

Editor, I&CS:

From my copy of *I&CS* I have become familiar with a number of your technical publications on control. I am particularly concerned with pneumatic control but I would like to obtain some elementary texts on electronics. Also, I would like to get some technical information on flow measurement, specifically on flow coefficients for segmental orifices.

P. R. Bennett,
Spruce Falls Power and Paper Co.
Kapuskasing, Ontario

hays

RAMBLINGS ON INSTRUMENTATION

Dear Mr. Ramblings,

I am a young engineer hopelessly in love with a Bangkok temple virgin sworn to a lifetime of celibacy to guard the sacred flame of Oom Fat. I am faced with a $350,000 liability judgement caused by my maternal grandmother driving my new Triumph through Tiffany's show window in a fit of pique at being cut from the Olympic bobsled team. I can't seem to solve the flow measurement problem in the molasses tank at Plant Four and I've been blacklisted in three clubs for a slip of the lip while being interviewed by Jack Paar.

Please, Mr. Ramblings, can you help me? How can I solve the flow measurement problem in the molasses tank at Plant Four?

Nervous

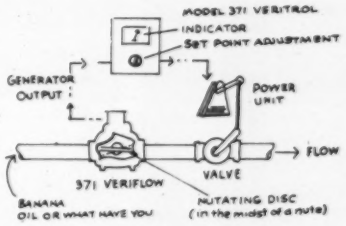
Dear Nervous,

Your problem is, unfortunately, all too common. If you could but see the heart-breaking letters in our mail, letters from presidents, treasurers, engineers, and just plain Board Chairmen . . . all seeking the peace of mind that comes with accurate, dependable, automatic measurement and control of the flow of liquids.

We can't help but think what a better place this old world would be if everybody simply used Hays Veriflow and Veritrol meters and took their wife out to dinner once a week. But the obvious always escapes us, doesn't it?

For your information, Nervous, the Hays Veriflow and Veritrol meters used in combination provide pinpoint rate-of-flow measurement, control and totalizing. The Veriflow flowmeter handles practically any type of liquid. Everything, in fact, from acetone to xanthophyll, including, of course, fish stick. We take the attitude that it's none of our business *why* these things need measuring. If someone is nosey about the flow of xanthophyll, well, measure away, that's our position. Just use a Hays Veriflow, Charlie, that's all.

The pin-point accuracy of the Hays Veriflow meter (within 2% even when measuring trickles) is largely due to the nutating disc piston which displaces a positive amount of liquid every time it nutes. (A nute seems to be pretty much the same as a wobble but don't try to tell our engineers *that.*) For an eyewitness view of a nute, see helpful illustration.



Helpful Illustration

We can supply the Veritrol and Veriflow meters custom embroidered and monogrammed for your application, however gooey or corrosive your liquid products may be. Our bulletin B347 restates the foregoing more forcefully. Glad to send it along. Hope this has been helpful, Nerv. Tell Grandma to hang in there for '64—bobsledding is *riddled* with politics.

- Hays will conduct an experiment with frightening implications at the ISA Show in San Francisco May 10-12th, using our new suppressed zero O_2 analyzer to analyze the breath of any passerby strong enough to blow up a balloon. Our first step in sociological research.
- A limited first edition of our new General Catalog is coming off the press (apparently an early Gutenberg model). First come, first served.

Phil Sprague Jr.
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 7 ON READER-SERVICE CARD

THE HAGAN CONCEPT OF THE AUTOMATIC PLANT

The concept of an automatic power generating station is receiving thoughtful consideration in today's world of power. Profit-conscious managements, aware of the attendant risks in the headlong approach to total automation, are closely examining the hardware available today—from a standpoint of performance, experience and reliability. They are asking searching questions about their process and its performance equations—questions that must be answered before managements can determine just how far and how fast they will proceed toward the goal of a fully automated plant.

Considerations on which the Hagan Concept is based are: *payout, usage and investment.* Eventual payout must be carefully balanced against cost, since even an optimum control-computing system compromises such factors as reliability and simplicity, accuracy and sensitivity. While a "push-button" plant is feasible, the number of times the button will be pushed during the life of the unit must be considered when weighing the capital investment in equipment. And since computer capacity will stand idle until all the control loops and associated hardware are proved in action, and operators gain the necessary experience, the timing on the purchase of the computer is important.

There is a plan of action that lies between the headlong approach, with its attendant risks, and the less costly but non-productive wait-and-see viewpoint. This compromise approach is the Hagan Concept—which provides for a *logical* succession of steps towards the automatic plant, with each step a complete function.

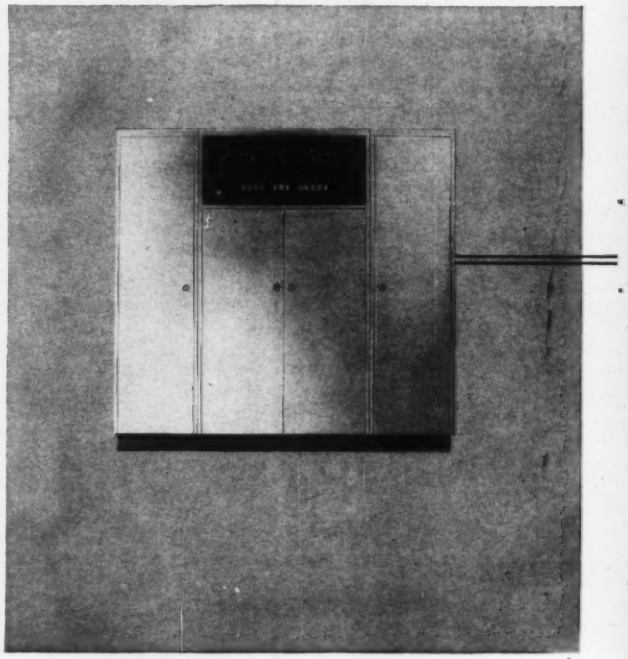
Step One: Install an analog (solid-state) electronic control system. This will take advantage of the proved reliability of analog-type control elements for actual plant operation, and will provide a workable foundation for proceeding to the next step. Maximum reliability is provided by an electronic control system utilizing magnetic amplifiers. Economy is achieved by utilizing compact remote control stations that hold panel space to a minimum.

Step Two: Install a scanning-logging system (solid-state). This can be done simultaneously with Step One. Obviously the data system must be compatible with the control system to gain economy of installation and operation.

The final steps toward complete automation—"computing facilities," "utilizing available processed data," "optimalization of the analog control loops," and "complete programming for automatic start-up and shut-down"—should be taken after start-up and commercial operation of the plant is accomplished. Anticipated 99% reliability of computer facilities is not good enough for continuous commercial operation. When based on actual plant operating experience, and when all final actuating devices have been proved reliable, programming for automatic start-up and shut-down can proceed intelligently and soundly.

We will be glad to send you a more complete exposition of the Hagan Concept. Write or phone Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Penna. Phone: WAlnut 2-3737.

HAGAN SOLID-STATE



SERIES 2000 KYBERNETES DATA SYSTEM

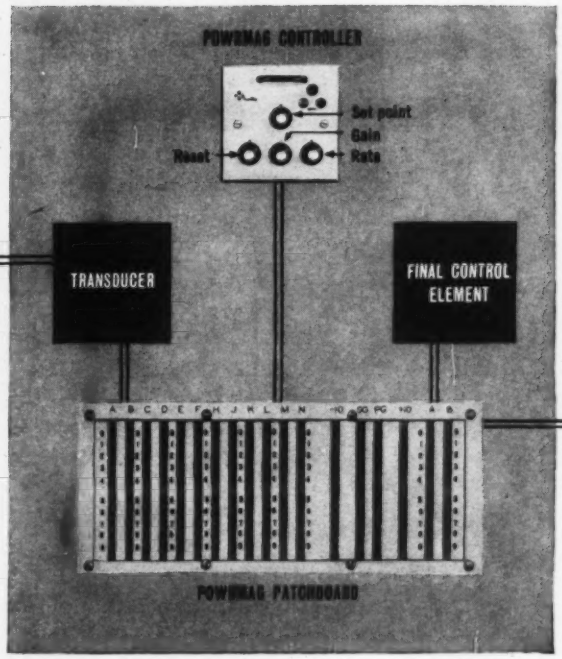
Completely compatible with the PowrMag Line, the Kybernetes Data Processing System encompasses all the necessary functions to perform logging, calculating and alarm scanning operations. Standard design includes linearization, square root extraction, AC to DC conversion, multiplication, division and digital alarm comparison. Kybernetes 2000 will handle inputs from thermocouples, AC and DC transducers and digital inputs. Input switching is handled by a relay matrix, so arranged that the failure of any input relay cannot invalidate the entire device.

Complete random access to *any* variable is immediately available. The system is completely isolated from induced voltages and from ground currents. A patented, all-electronic self-balancing DC amplifier provides elimination of noise, yet has excellent frequency response. Designed for maximum utilization, the Kybernetes system provides great flexibility. By utilizing parallel inputs, amplifiers and storage devices, it is possible to perform the functions of totalization and computation *without interrupting the normal logging, alarm scanning and visual display functions.*

Pinboard programming on a pre-wired board permits easy selection of the desired operational characteristics, such as: full-scale ranging, trend logging, alarm set points, or function programming of such items as linearization, square root extraction, computations or number of digits to be logged.

FOR MSP-163 CIRCLE 8 ON READER-SERVICE CARD

CONTROL AND DATA PROCESSING

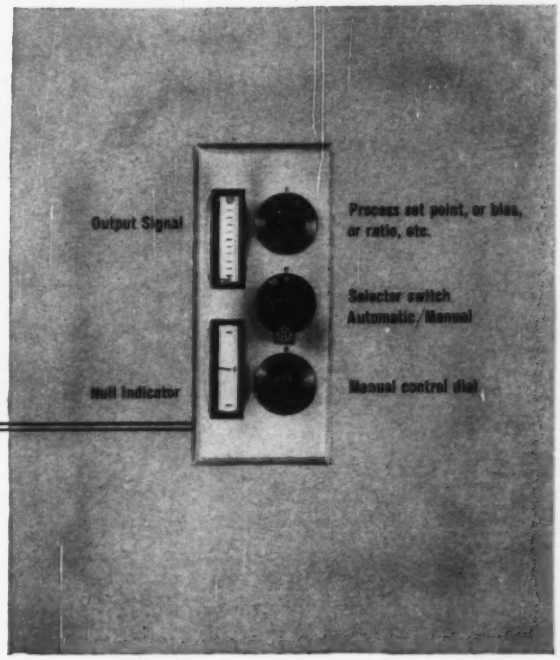


HAGAN POWRMAG CONTROL SYSTEM

A solid-state, Analog Computer Control consisting of four basic elements, PowrMag (magnetic amplifier) combines reliability with extremely low maintenance. A typical system would include:

1. Input Transducers for converting variables into 1-9v DC electrical signals.
2. Analog Control Computer consisting of operational magnetic amplifiers, which, in association with plug-in passive network components, perform all computing functions, including addition, subtraction, division, integration and differentiation.
3. Remote Control Stations to provide for remotely established set points as well as required manual control operations.
4. Final Control Elements, such as electro-pneumatic or electro-hydraulic operators.

Hagan PowrMag control systems are extremely flexible, easy to install, and foolproof. All components plug in and are completely interchangeable. Interconnections are made at a central patchboard by means of taper pins. Requiring a special tool for insertion or removal, the taper pins are foolproof and tamper-proof. Each connection is identified on the patchboard by an alphanumerical combination. Changes in the system are readily accomplished, and more components or loops can be added easily.



REMOTE CONTROL STATION

Easy to operate, cleanly designed, the station requires no operator memory. Front mounting and removal make it ideal for use in compact console installations. Whole station is 2¼" x 5¼"; half station is 2¼" x 3⅛".

Each station uses 12-wire color-coded electric cable with M-S type connector. Full station may contain two single or ganged potentiometers, one switch and two meters. Half stations provide set point, bias or ratio dial plus output signal indicator.

Today PowrMag and Kybernetes equipment is being built or is at work for a wide variety of industries. PowrMag installations include complete boiler, metallurgical furnace, glass furnace and glass fiber die control systems. Kybernetes installations are performing such functions as data logging, processing and calculating as well as temperature monitoring in refineries, power plants, municipal water works and chemical plants. A letter or phone call will put Hagan experience to work on your problem.

Write for PowrMag Bulletin MSP-163 or Kybernetes Bulletin MSP-161.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA

HAGAN DIVISIONS: CALGON CO. — HALL LABORATORIES — BRUNER CORP.

FOR MSP-161 CIRCLE 9 ON READER-SERVICE CARD

Bailey f/b-*LINE* Differential Pressure Transmitter (Force Balance Mechanism)

Bailey f/b-*LINE* Flow Transmitter (Force Balance Mechanism)

Two new Bailey *f/b-LINE* Transmitters

permit new accuracy in measuring flow and differential pressure

Pneumatically transmits rate of flow—or differential pressure—measurements to indicating, recording, and/or controlling equipment at remote stations. Transmitters consist of a diaphragm measuring mechanism and a force balance pneumatic transmitting unit.

APPLICATION

For steam, water, air, gases and other fluids producing differentials across primary elements from 0-2 in. H_2O to 0-2000 in. H_2O at maximum service pressure of 50, 1500, and 5000 psig.

FEATURES

Transmits a Signal Directly Proportional to Rate of Flow. Uses receiver with uniformly-graduated chart or scale. Eliminates need for external square-root extractors or characterizers.

10 to 1 Turndown. Differential range of each diaphragm measuring element may be changed by factor of 10 to 1; e.g., 0-20 in. H_2O diaphragm may also measure 0-2 in. H_2O.

Screwdriver Adjustments. Range and zero adjustments readily accessible. Range may be changed with screwdriver adjustment.

Overpressure Protection. Protects against full service pressure applied to either side of diaphragm.

Fast Response. No viscous dampers needed, so speed of response is very fast.

Corrosion Resistant. For maximum differentials between 20 and 2000" H_2O, all parts in contact with process fluid may be stainless steel. No sealing fluids or sealing diaphragm required.

Good Stability. Reset type boosters give good stability with high gain.

Versatile Mounting. May be mounted on process piping, wall, or separate mounting pipe using same bracket.

For additional information, call your local Bailey District Office, or write direct. G46-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 10 ON READER-SERVICE CARD

Editor, I&CS:

REF: I&A, Vol. 31, No. 7, Item #A-324

According to the inquiry you would welcome suggestions on a precision method of measuring diameters of machine rolls. Our organization has done considerable research in precision measurement using a combination of optics and electronics.

If I understand your most precise measurement problem correctly, you are required to measure a roll 60″ in diameter accurately to within 0.000050″ (fifty, one millionths of an inch).

This is within a workable figure since we have been dealing with linear measurement increments of 0.000021 (twenty one, one millionths of an inch). This measurement has a theoretical accuracy of one part in twenty million. The practical accuracy of this measurement depends, of course, on the mechanical perfection of the measuring device you would require, the perfection of its contact with the rolls, temperature of the roll, and the measuring device and other environmental conditions.

Yours very truly,
John T. Ferris,
Southwestern Industrial Electronics Co.
Houston, Texas

READER INQUIRIES

Hi-voltage A-c Meter

Project engineer of electrical manufacturing company seeks voltmeter to register from 5000 to 10,000 volts. A-613

Humidity, Atmospheric Pressure Recorders

Engineer of electric utility company seeks barometer and relative-humidity indicator that has or can be modified to have electrical output for feeding into multi-channel recorder. A-614

Resistor Winding Kit

Purchasing agent of Hawaiian electronics manufacturer seeks kit possibly containing small spools of resistance wire ranging from approximately 1 to 20 ohms/ft, also having bobbins and a hand winding jig. A-615

Miniature Elapsed Time Indicators

Importer in Sweden wishes to receive bids for 1000 elapsed time indicators, 115 v/400 cps, approximately 1″ dia x 3″ lg, meeting Air Force specs and indicating to 9999.9 hr. Only mass-produced items are of interest. A-616

CIRCLE 11 ON READER-SERVICE CARD →

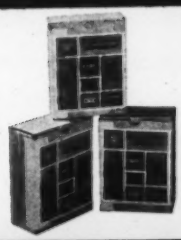
PROCESS YOUR OSCILLOGRAMS FAST . . . *ANYWHERE!*

For on-the-spot processing of oscillograph records, there's no beating CEC's swift new 23-109A Portable Oscillogram Processor. It's the only completely portable, completely self-contained "darkroom" that delivers dry, developed, ready-to-use oscillograms in the field . . . in broad daylight. Fact is, 90% of all oscillograms processed in field operations are processed on these units.

It's motorized for automatic operation . . . needs no external water supply . . . is available for 115- or 230-volt AC operation.

And the liquid chemicals kit developed for the 23-109A is equally remarkable. You asked for it . . . CEC delivers a kit containing concentrated developer and stabilizer *solutions* in high-strength, throwaway plastic envelopes. No mixing, no handling, no irritating odors.

For complete information on the 23-109A, call your nearest CEC sales and service office or write for Bulletin CEC 1537-X7



This new liquid chemicals kit assures fast, safe preparation of solutions for the 23-109A Oscillogram Processor. It is described in Bulletin CEC 1629-X1.

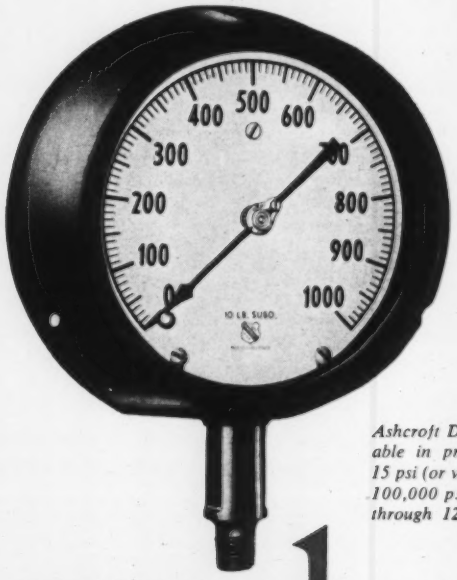
Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service



Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MAXWELL MANNING M&M & MOORE, INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 12 ON READER-SERVICE CARD

READER INQUIRIES

Panel-mounted Clock

Engineer seeks 4½" x 4½" electric clock (115 v/60 cps) with black arabic figures on white dial, black hour- and minute-, and red second-hand, self starting at 90% of rated voltage, and visual signal if power is interrupted, in a case with dull black finish for flush mounting on ⅛" steel panel. A-617

Portable Pressure Recorder

Consulting engineer seeks portable pressure recorders for field use in water works distribution systems with chart drive other than line-supplied or with hand-wound clock, or using inverter from 6 or 12 vdc to 110 vac. A-618

Hi-voltage D-c Meter

General supervising engineer of electric utility company seeks electrostatic voltmeter for checking precipitator voltages. Scale range to be 0 to 50,000 v. A-619

Mass Spectrometer

Supervisor in purchasing department for chemical manufacturer seeks large mass spectrometer comparable to CEC Model 21-010A or Bendix Models 12 or 14. Foreign makes acceptable. A-620

Small Ball Check Valve

Engineer seeks small ball check valves similar to Imperial No. 43-F, tube to male pipe thread, in stainless steel, nylon, or other non-corrosive metal or plastic. A-621

Fractionator Instrumentation

Process engineer in Greece seeks data on fractionator instrumentation. A-622

Testing Machine

Engineer with tile manufacturer seeks cross bending and testing machine to test oxychloride cement. A-623

Air Flow Meter Relays

Resident representative of Italian d-c locomotive manufacturer seeks air flow meter relays to keep open a circuit at 96 vdc for a 45-w lamp. Air velocity range is 10 meters/sec. Signal to be on in the event of lack or inverse circulation of air. Must withstand heavy vibrations. A-624

Float Regulator

Patent consultant seeks "very small type of float regulator, the mechanism of which can withstand steam and hot water." A-625

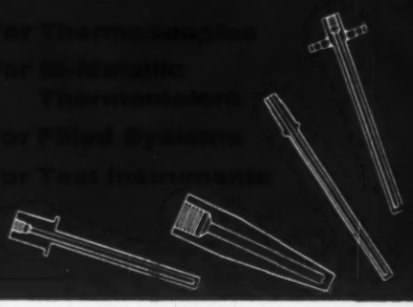
Thickness Measurement

Chief test engineer of rubber manufacturer seeks instrument to measure wall thickness of steel or stainless-steel vessels, accessible only from inside, to check worn areas for safety. A-626

WHEN DEPENDABILITY IS A REQUIREMENT...

TRINITY THERMOWELLS

Trinity Thermowells assure the greatest degree of dependability through the most careful material selection and certification, plus outstanding manufacturing and inspection techniques. Trinity Thermowells are products of the world's leader and pioneer in the design, development, and manufacture of thermowells.



BOXED AND IDENTIFIED FOR YOUR CONVENIENCE

Every standard Trinity Thermowell is packaged in an easy-to-store box that maintains factory-fresh condition of the well. Complete identification is provided on end panel for on-the-shelf selection.

WITH FAST, FAST DELIVERY

Trinity maintains a complete stock of thermowells for fast customer service. Orders filled and shipped within 24 hours.

Plus TRINITY THERMOCOUPLES

Trinity manufactures a complete line of thermocouples for every need in all configurations and wire types.

*WRITE FOR THERMOWELL AND THERMOCOUPLE MANUAL...

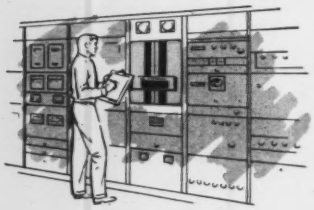
TRINITY

Heat-Les Dryers • Heat-reactivated Dryers
Thermocouples and Thermowells

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

CIRCLE 13 ON READER-SERVICE CARD

the pb 250 / a general purpose,



The design of the PB 250 enables it to be mounted as a systems component in 31½ in. of a standard relay rack.

SPECIFICATIONS

TYPE
Serial, binary, internal program

COMMAND STRUCTURE
Single address with index register

NUMBER OF COMMANDS
46

OPERATION TIMES

Add/subtract	12 microseconds
Multiply	276 microseconds (max.)
Divide	252 microseconds (max.)
Square root	252 microseconds (max.)
Average access time	1,540 microseconds
Average access time to fast memory	96 microseconds
Maximum operational rate	40,000 instructions per second

WORD LENGTH
21 bits plus sign

MEMORY
Type:
Magnetostrictive delay lines
Capacity:
1,808 words (Up to 15,888 words internal storage at additional cost. 16,384 words external core memory also available.)

INPUT-OUTPUT
Standard:
Automatic alphanumeric typewriter
Paper tape punch and reader
32 control outputs
30 control inputs
High-speed block input-output (85 KC word rate)
Optional:
High-speed paper tape punch and reader
Magnetic tape units (six maximum) employing IBM 700 series format
Punched card equipment
Analog-to-digital converters
Digital-to-analog converters

PHYSICAL DESCRIPTION
30 in. high, 19 in. wide, 24 in. deep
110 pounds
Fully solid-state construction
Completely modularized

POWER REQUIREMENT
115 volts, 60 cycles, at 100 watts

Completely Solid State Internally-Stored Program

From Packard Bell Computer comes the first truly "second-generation" medium-scale computer. The PB 250 is a general purpose digital computer that may be applied to an extremely broad range of scientific, industrial, and military problems. The PB 250 combines a large, expandable memory and a versatile command structure with a computing speed in the microsecond range.

A FEW OUTSTANDING FEATURES OF THE PB 250

MICROSECOND SPEED

Computing speeds of the PB 250 rival those found only in expensive, large-scale systems. Addition and subtraction require 12 microseconds. Multiplication and division are variable length commands requiring 276 and 252 microseconds, maximum, respectively. All floating point operations require less than three milliseconds.

EXPANDABLE MEMORY

Minimum memory capacity of the PB 250 is 1,808 words, including one 16-word fast access line. The memory is economically expandable to 15,888 words internally, plus 16,384 words of external core storage.

VERSATILE COMMAND STRUCTURE

The extensive command list of 46 instructions contains 14 data transfer commands, 8 arithmetic commands (including divide and square root), 14 logical and program transfer commands, and 10 input-output commands.

SIMPLE PROGRAMMING

Programming simplicity is achieved by single-address instructions, command indexing, and automatic double precision operations. Symbolic programming routines are supplied at no extra cost with the PB 250.

FLEXIBLE INPUT-OUTPUT SYSTEM

The PB 250 is adaptable to a wider range of peripheral equipment than any computer in the low-priced field. This equipment includes high-speed tape readers and punches, magnetic tape units, card readers and punches, printers, analog-to-digital and digital-to-analog converters. Standard equipment includes an automatic typewriter, paper tape reader, and punch.

EXCEPTIONAL RELIABILITY

Maximum reliability is achieved through conservative solid-state design, a small component count (less than 350 transistors), and absence of moving parts.

All memory operations are parity checked.

SYSTEMS INTEGRATION

Flexible input-output design enables the PB 250 to be easily integrated into existing systems, either on- or off-line.

The PB 250 may operate as a universal format-to-format converter.

CIRCLE 14 ON READER-SERVICE CARD

microsecond computer for $30,000

PACKARD BELL COMPUTER

A Subsidiary of
Packard Bell Electronics

1905 ARMACOST AVENUE, LOS ANGELES 25, CALIFORNIA • GRANITE 8-4247

©2-22-60 PB

CIRCLE 14 ON READER-SERVICE CARD

Continued upswing in announced expenditures for construction of new laboratories in chemical industry is significant. Total research budget last year topped $600 million. The three-year figure of $220.485 million for laboratory construction in this year's chemical industry survey shows a substantial rise over the $157.170 million listed last year and the $107.215 million announced the year before. The industry has been marketing more than 400 new products annually during the past several years.

1960 outlook for pipelining: U. S. natural gas—13,550 miles compared with 13,500 miles in 1959; U. S. Crude—1,100 miles compared with 1,900 miles in 1959; U. S. products—3,000 miles compared with 1,300 miles in 1959; Canadian natural gas—1,100 miles compared with 950 miles in 1959; Canadian crude—600 miles compared with 280 miles in 1959; and foreign—5,600 miles compared with 6,700 miles in 1959, says Oil Gas Journal.

Four Computer Language Translator Systems are now in operation—U. S. Navy David Taylor Model Basin; North American Aviation Inc. Missile Division, Downey, Calif.; System Development Corporation, Santa Monica, Calif., (SAGE system); Martin Co., Denver, Colo.

Electric power total will more than double its present 700 billion kw-hrs by 1970, says D. G. Mitchell of GT&E Corp. Electric manufacturing industry also will double its present $25 billion total.

Communications equipment market for 1959 and 1960 is predicted by J. Thompson of A. D. Little, Inc., as follows (millions of dollars):

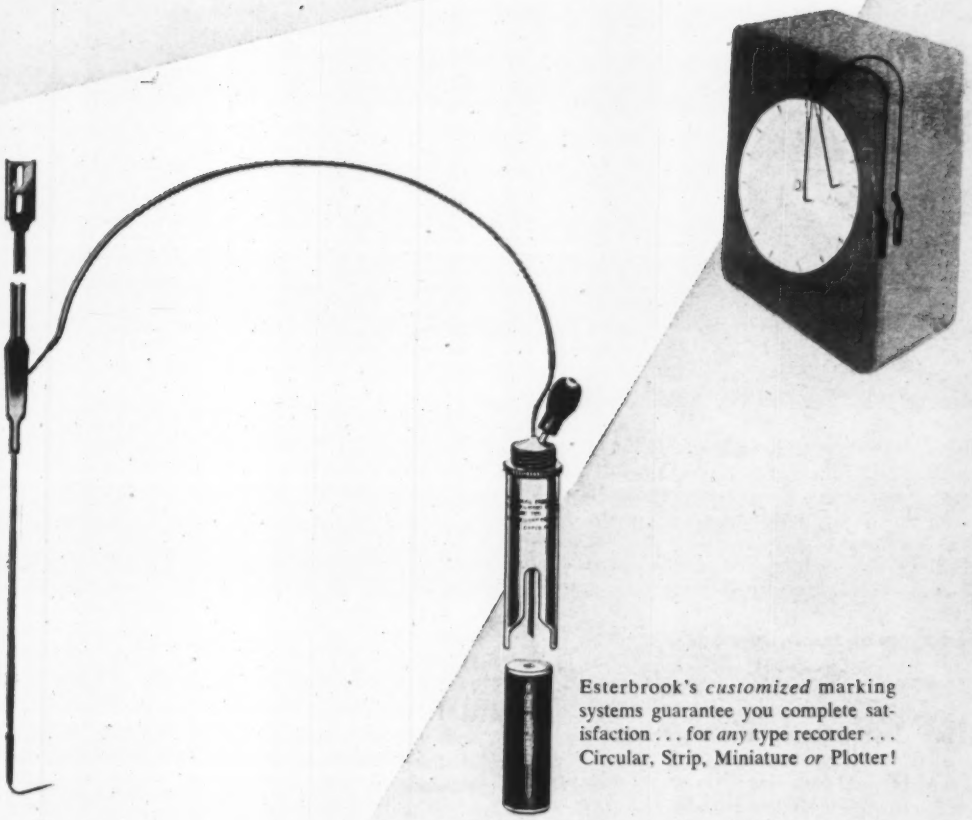
	1959	1960
Mobile radio	$95	$113
Broadcast	55	60
Aviation (excluding airport control)	50	55
Microwave	30	40
Intercoms	30	35
Marine	10	12
Other	10	10
Total	$280	$325

Sales of semiconductor products in the United States by all manufacturers have doubled every year for the past decade, and will be over $500 million in 1960, says Dr. Guy Suits of General Electric. Also, about 10,000 scientists throughout the world are engaged in semiconductor research today—Russia (24%); the United States (21%); the United Kingdom (11%), and Japan (10%) do in aggregate 66% of world research on the solid state.

Education Directory, U. S. Office of Education, lists 226 institutions of higher education in US and parts which confer engineering degrees. Engineering enrollment in these numbered 289,680 in 1958 (compared with 297,077 in 1957). This is drop of 2.5%. This includes 256,779 enrolled for first-level degree (compared with 268,761 in 1957), 28,138 for master's degree, and 4,763 for doctor's degree.

Production and shipments of electronic components in first half of 1959 are 30% above same 1958 period, 15% above figures for last-half of 1958, says Commerce Dept. (Electronics Div.) and Electronics Production Resources Agency (Defense Dept.).

NEW! Meter Recorder Marking System with a Slip-In Cartridge!



Esterbrook's *customized* marking systems guarantee you complete satisfaction . . . for *any* type recorder . . . Circular, Strip, Miniature *or* Plotter!

Customized for your meter recorder by Esterbrook

Give your customers the big benefit of *ink cartridge convenience* and a century of applied experience in the recording product you manufacture!

Now—Esterbrook's Technical Products and Instrument Division will custom-design and build a new marking system for *your* product.

The result: no more breaking down . . . no more hand fixing . . . time and money saved! With Esterbrook's new *customized* meter marking system your customers will conserve operating time . . . *and* you'll receive the free design time and engineering assistance of experts!

For further information write to :

Technical Products and Instrument Division
The Esterbrook Pen Company • Camden 1, N. J.

TECHNICAL PRODUCTS AND INSTRUMENT DIVISION

The Esterbrook Pen Company

CAMDEN 1, NEW JERSEY

CIRCLE 15 ON READER-SERVICE CARD

ICS NEWS

New Look in Control Rooms

BEVERLY HILLS, CALIF.—RW-300 COMPUTER CONTROL SYSTEM installed in the control house of Goodrich's vinyl chloride unit at Calvert City, Ky., shows

the "new look" with the computer in the foreground, the operator's console at the left, and a conventional graphic panel in the rear. The computer is now exercising closed-loop control over the vinyl chloride monomer production unit, as well as scanning process variables and logging instrument readings and computed values. In the near future it will also control the acrylonitrile unit at the same plant.

CIRCLE 180 ON READER-SERVICE CARD

Radio Science Program

DOWNIE, CALIF.—A new scientific and radio program was aired over radio station KRKD, Los Angeles, on March 6. The program, "H. H. Harberts Engineering and Scientific Societies News," will be broadcast each Sunday evening between 6:15 and 6:30. The Los Angeles Technical Societies Council, and its 33 member professional, technical, and engineering societies (including ASQC, IRE, AIEE, etc.) is assisting with program planning. The program features news headlines with commentary on the significant events of interest to science and engineering; news of societies' activities, meetings. conventions, conferences, etc.

EAI (ELECTRONIC ASSOCIATES) announces two spring courses on analog computer applications: The first one, April 4 to 15, will deal with process and process control studies, the second one, June 6 to 17, will be devoted to design of aircraft, missiles, and weapons systems. Each course continues for two weeks, and is intended for persons who have graduated from a university engineering or scientific course and who have two or more years experience in a technical field. For information write Director of Training, Princeton Computation Center, Electronic Associates, Inc., Princeton, N. J.

CIRCLE 181 ON READER-SERVICE CARD

High-School Students Learn Digital Computers

TULSA, OKLA.—When Tulsa announced a computer course for mathematically-minded students, more than 100 boys and girls applied for the privilege of spending after-work hours and every other Saturday morning in class without receiving credit toward graduation. Thirty-two seniors were lucky enough to be selected on account of a competitive examination.

The course, which is taught by members of the Tulsa Chapter of the Association for Computing Machines with the sanction and endorsement of the Board of Education, has the cooperation of eleven local industrial and business firms. IBM leased the necessary equipment. The course will run through the academic year of 1959/60, with the main aim to teach the students to use computers as a tool. It is hoped that through these efforts a number of students will be channeled into science courses in college. Picture shows students examining the input-output unit.

JAMESBURY CORP. had a color-sound slide film made showing unique features and advantages of their "double-seal" ball valves. This 20-minute film will be shown by sales executives throughout the country.

CIRCLE 182 ON READER-SERVICE CARD

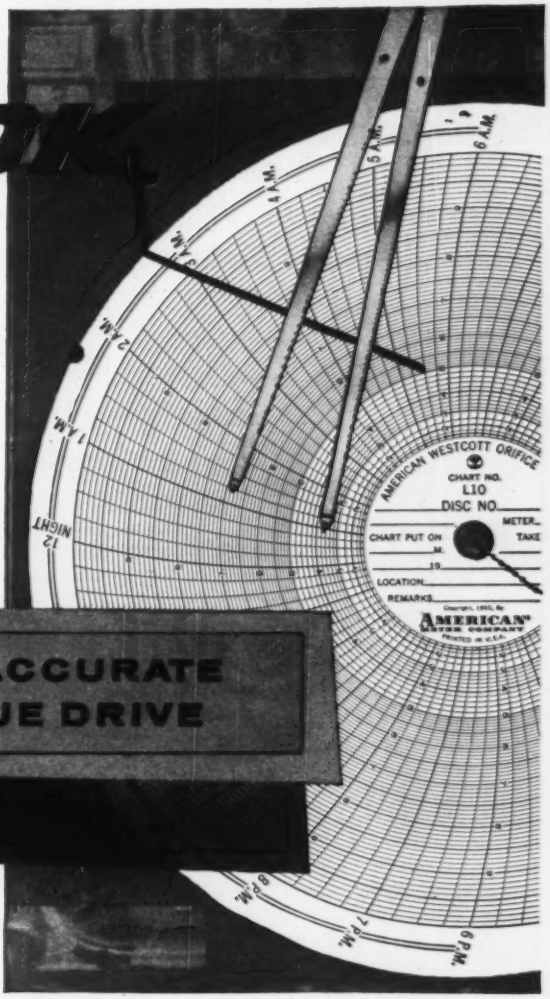
HAGAN will install an advanced PowrMag system on a 2-zone slab heating furnace at the plant of an eastern steel producer in mid-1960. This is believed to be "the first solid-state, electronic combustion control system applied to the iron and steel industry." The complete system includes controls for zone temperature, zone fuel/air ratio, furnace pressure, recuperator temperature balance and air pressure, panels and electronic recording instruments, all manufactured by Hagan Chemicals & Controls, Inc., Box 1346, Pittsburgh 30, Pa.

CIRCLE 183 ON READER-SERVICE CARD

BAILEY METER CO. jointly with Kimberly-Clark Corp. has developed the Bailey Continuous Freeness Recorder for the continuous measurement of pulp freeness, heretofore determined only through lab tests. Freeness varies with consistency of the stock sample, and the device has been applied successfully to four different types of pulp over ranges from 150 cc to 600 cc freeness. The instrument will be marketed in 1960 by Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 184 ON READER-SERVICE CARD

AMERICAN®
GASCLOK
POWER DRIVE



Check these features--

- **Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations.**
- **Constant high power...more than 20 times the torque delivered by conventional spring-wound mechanisms.**
- **Timing accuracy continuous...no heavy "mainspring" to weaken or run down...unaffected by a ± 20% variation in supply pressure.**
- **Self-starting...no winding or priming of power unit.**

VERSATILE • ACCURATE
HIGH TORQUE DRIVE

- **Flexibility...ideal as original or replacement equipment for strip chart and conventional circular chart instruments.**
- **Built-in durability...timing mechanism internally sealed to prevent corrosion...large area internal ports prevent clogging.**
- **Rugged dependability...all power unit parts exposed to gas are aluminum or stainless steel...inherently explosion proof.**
- **Economical...normal air or gas consumption 5 cfh...operating pressure 5 psi...rotation 2 rpm.**

Then ask
your American representative how the versatile **GASCLOK** can provide new metering accuracies and economies for you.

AMERICAN METER CO

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood • IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

CIRCLE 16 ON READER-SERVICE CARD

AMPERITE PREFERRED

by design engineers—because they're

MOST COMPACT • MOST ECONOMICAL

SIMPLEST • HERMETICALLY SEALED

Thermostatic DELAY RELAYS

2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to + 70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

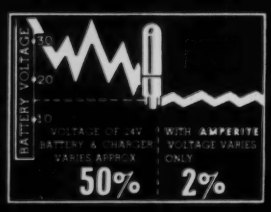
Also—**Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

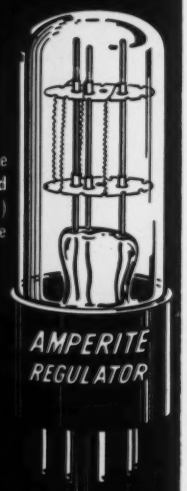
TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.** Standard Delays

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55° to + 90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.

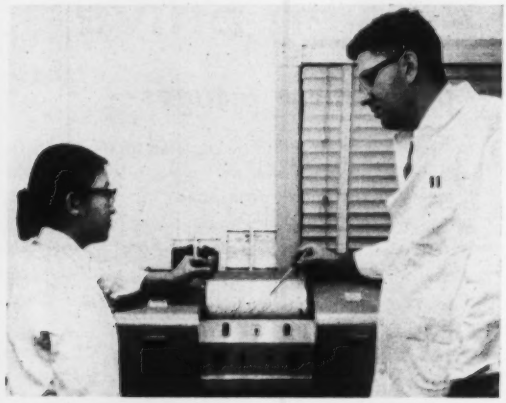
Telephone: CAnal 6-1446

In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

RELAYS—CIRCLE 17 ON READER-SERVICE CARD
REGULATORS—CIRCLE 18 ON READER-SERVICE CARD

Cranberry Testing Program

FALLS CHURCH, VA.—When it was discovered last November that some cranberry growers had used aminotriazole as a weed killer and toxicological studies had revealed its possible potentialities of leading to cancer in humans, a crash program was initiated at



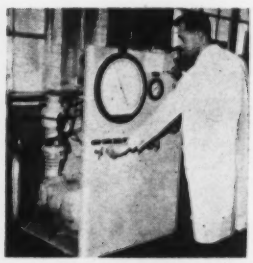
Hazelton Labs.

According to a method outlined by the Food and Drug Administration a small amount of cranberry sauce was weighed out of each can and prepared for analysis by a spectrometer. The spectrum of the cranberry sample was then compared to graphs of known standard solutions of aminotriazole. The total procedure took less than ten minutes. Perkin-Elmer Corp., Norwalk, Conn. supplied the spectrometers.

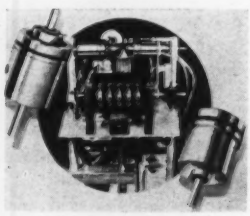
CIRCLE 185 ON READER-SERVICE CARD

PRESSURE PRODUCTS INDUSTRIES has designed and built a portable system for high-pressure testing by the use of non-contaminating gas which the Missile Div. of Minneapolis-Honeywell at Pottstown, Pa. is applying to missile components. Its major constituents are a diaphragm gas compressor and a ½-cu-ft accumulator. All valves, fittings, tubing, regulators, gages, electric switch gear (Class I, Group D), etc., are mounted on the control panel.

CIRCLE 186 ON READER-SERVICE CARD



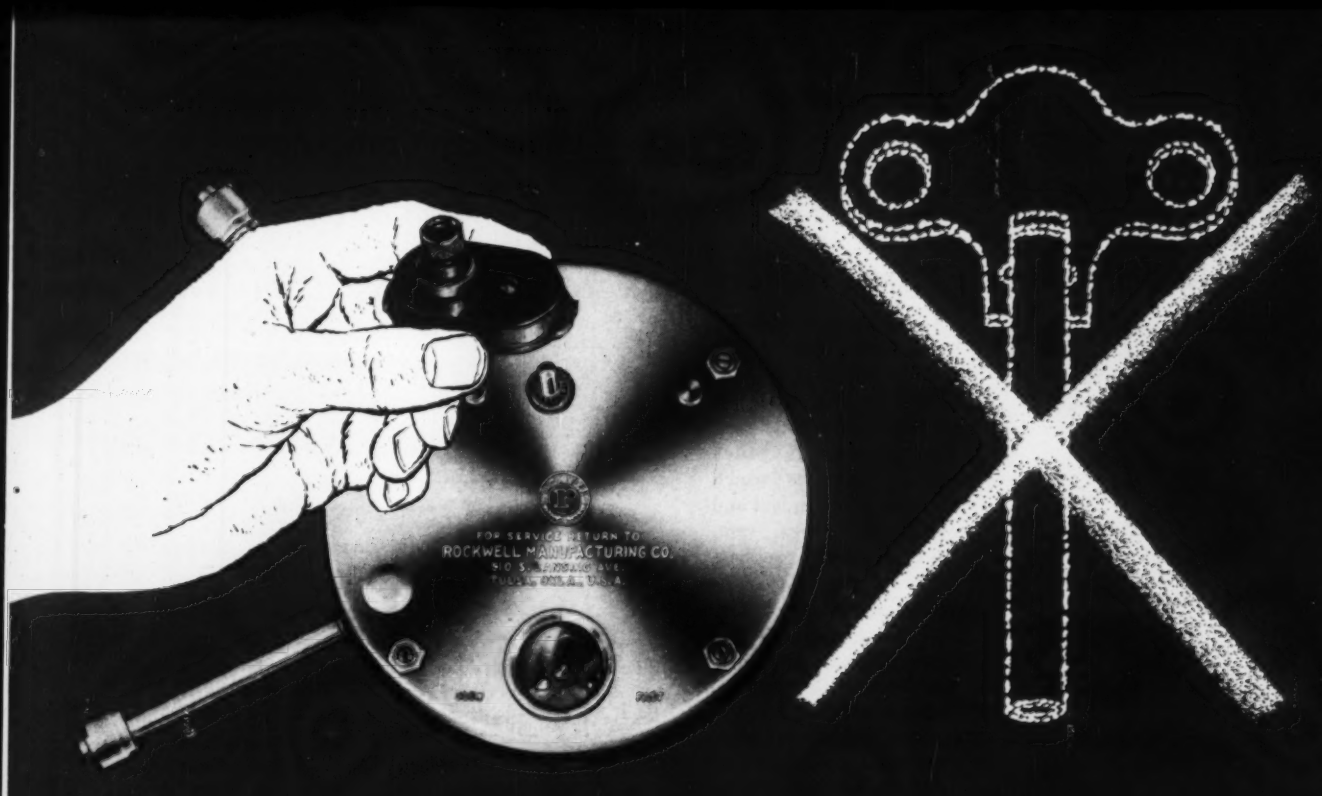
High-Pressure Testing



Miniature Clutch

SIMPLATROL PRODUCTS is furnishing miniature electric clutch and brake assemblies to **J. W. DICE CO.** which are utilized in the Model PDR Carson-Dice Automatic Electronic Micrometers. These assemblies serve to brake within 7 msec. the spindle of a digital readout counter and to disengage a motor-driven screw which makes contact with the part to be measured. Thus objects are measured within 10 millionths of an inch.

CIRCLE 187 ON READER-SERVICE CARD



Illustrating how speed changing turrets are applied to the chart arbor

You never need to wind the Rockwell Gas Drive

GAS (OR AIR) POWERS THIS NEW CHART TIMING DRIVE. With it you can forget the costly chore of periodic winding. It's completely self-starting, self-contained. You can use the Rockwell Gas Drive with profit and gain accurate, automatic operation of recording charts on practically any make orifice meter, gas lift intermitter, pressure recorder or temperature gauge. It is particularly applicable for remotely located instruments.

Since the Rockwell Gas Drive consumes only 6 cubic feet of gas in 24 hours it is economical to use—safe, too, for there is no exhaust problem.

The Gas Drive operates on a pressure range of 15-25 psi and delivers 15 in. lbs. of torque to the main arbor which rotates once every 24 hours. Geared turrets which snap onto this arbor provide optional speeds of 2, 3, 4, 6, 12, 48 or 72 hour, 7 or 8 day rotation. So with a stock of Rockwell Gas Drives, plus a selection of economical turrets, you can serve all your instrument needs. Get facts now. Write Rockwell Manufacturing Company, Pittsburgh 8, Pa. In Canada: Rockwell Manufacturing Company of Canada, Ltd., Guelph, Ontario.

◀ Rockwell Gas Drive powers this typical intermitter

GAS DRIVES. CHART DRIVES

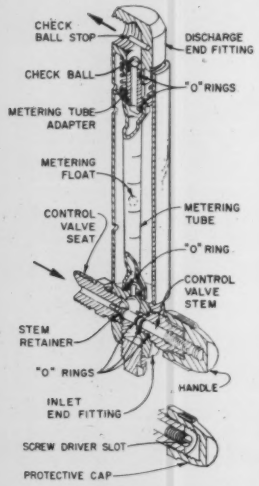
another fine product by

ROCKWELL

CIRCLE 19 ON READER-SERVICE CARD

ICS BRIEFS

Glass Tube Type Purge Meters

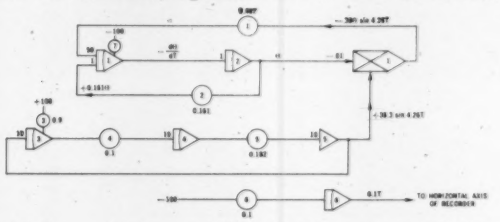


Glass Tube Purge Meters are low capacity flow meters specially constructed to withstand the toughest industrial uses. Their design includes unique features which make them convenient and reliable in purge, vent, bleed, or other applications . . . A wide choice of instantly interchangeable metering tubes and floats cover a flow range of—Water: 0.01 to 30.0 gallons per hour. Air: 0.12 to 125.0 standard cubic feet per hour . . . (*From new 4-page Bulletin TP-1-RM, Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.*)

CIRCLE 188 ON READER-SERVICE CARD

How to Use and Program Analog Computers

To illustrate the scaling and programming techniques, let us investigate . . . the problem of an inverted pendulum with a sinusoidal displacement at the point of support (which) is described by an equation with time-varying coefficients . . . For an inverted



pendulum with a periodic displacement applied at the point of support, the equation assumes the form

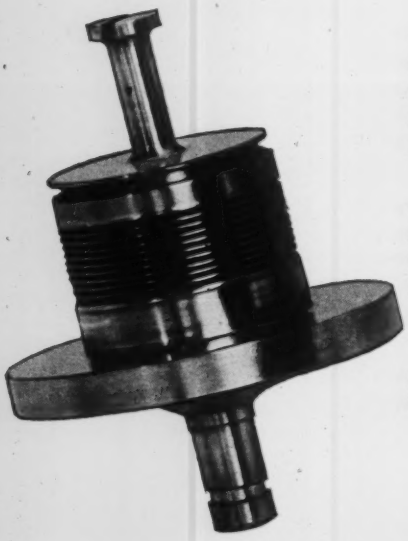
$$\frac{d^2x}{dt^2} - [A + F(t)]\,x = 0.$$

The loop composed of amplifiers 3 through 5 is used to generate the pivot excitation signal, 38.3 sin 4.26T . . . The voltage generated by amplifier 5 represents the derivative (with respect to T) of that generated by amplifier 3 . . . By altering the coefficient potentiometers in the computer diagram the region of stability can be quickly investigated . . . (*From new 4-page "Tech Notes No. 2," Donner Scientific Co., Concord, Calif.*)

CIRCLE 189 ON READER-SERVICE CARD

FORMWELD® (Welded)

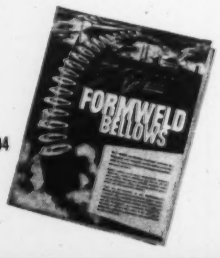
ONLY *Robertshaw* gives you this



Only a welded bellows like FORMWELD can give you the accuracy and stronger physical properties you need for many modern applications. Proper selection and welding of any suitable alloy now give you a premium bellows for heats above 1000°F . . . for pressures in the 3000 psia range . . . for service in severe corrosive atmospheres or under high shock and vibration conditions.

Zirconium, Inconel-X, Titanium, Hastelloys, Monels, Ni-Span-C and several stainless steel grades are among the alloys available. Other outstanding advantages include closer control of effective area, lower spring rates, greater resistance to deformation under high loads and much lower hysteresis. Robertshaw saves you money by producing the complete "package" . . . in bellows sizes from ½" O.D. to many times that size.

Remember, only Robertshaw can recommend and custom-engineer *either* type of metallic bellows that will do your job best.



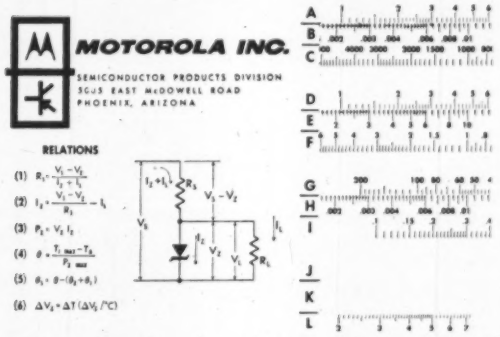
WRITE FOR FORMWELD BELLOWS BULLETIN F704

FOR BULLETIN F704 CIRCLE 20 ON READER-SERVICE CARD

Silicon Zener Diodes

There are at least two devices in existence which will provide good voltage regulation in a very simple electronic circuit. One of these is the familiar gaseous tube regulator . . . the other is the zener diode . . .

In the zener diode regulator, it is only necessary that the supply voltage exceed the zener voltage by some usful amount, usually only a few volts . . . The gaseous

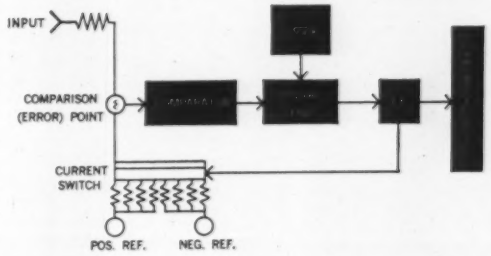


regulator tube volt-ampere characteristic is established by the design and construction of the tube . . . (and) the minimum voltage level which can be obtained is about 70 volts. Zener diodes are not subject to these limitations. (*From new 125-page Silicon Zener Diode Handbook," and Slide Rule Calculator (price* $1.00) *Motorola, Inc., Semiconductor Products Div.,* 5005 *E. McDowell, Phoenix, Ariz.*)

CIRCLE 190 ON READER-SERVICE CARD

Semiconductor Digitizers

Adage has applied the name "Voldicon" to a family of high-speed, all semiconductor, current balancing devices that use digital logic and readout for high-speed precision measurement of analog signals. During



a Voldicon conversion, the signal input current flows through an input resistor to a comparison point. A comparator senses the polarity of the comparison point and provides an error signal to the digital logic. In response to a sequence of clock pulses, the digital logic connects a series of digitally weighted precision resistors between the comparison point and an internal reference . . . (*From new 6-page brochure, Adage, Inc., 292 Main St., Cambridge 42, Mass.*)

CIRCLE 191 ON READER-SERVICE CARD

FORMFLEX* (Hydraulically Formed)

choice in metallic bellows!

Only a Robertshaw FORMFLEX seamless metallic bellows or "packaged" metallic bellows, made in the industry's most up-to-date production facility, can give you the quality you want and the performance required!

Robertshaw is now able, through its Bridgeport Thermostat Division, to meet your requirements for bellows as small as ⅛" O.D. In addition, Robertshaw can custom-engineer and produce bellows in any quantity . . . with consistent quality from unit to unit and shipment to shipment. Widest choice of bellows metals to provide the desired strength and performance characteristics. Finest testing equipment and procedures known.

Miniature sizes of ⅛", ¼" and 5/16" O.D., plus larger sizes to several inches O.D. Cost savings are possible when Robertshaw produces the complete "package". Remember, only Robertshaw can recommend either type of bellows without bias.

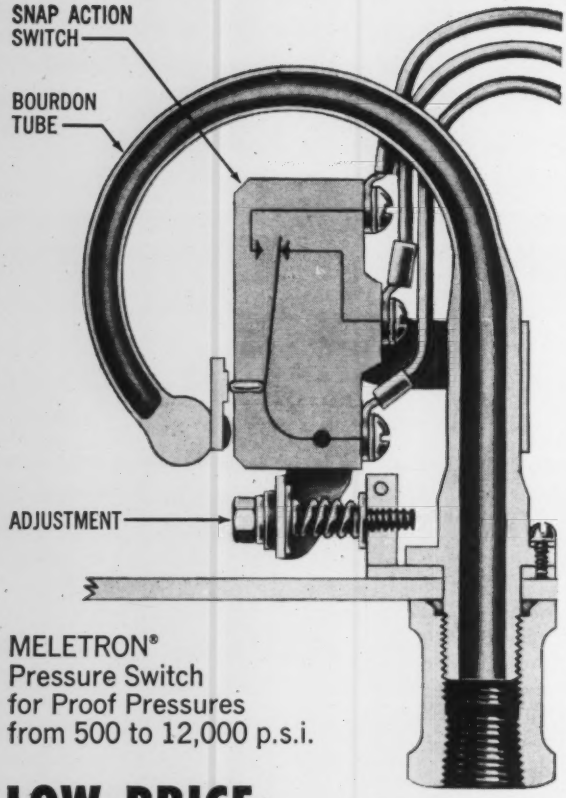
*Registration pending

WRITE FOR FORMFLEX BELLOWS BULLETIN F104

Robertshaw MR. CONTROLS

BRIDGEPORT THERMOSTAT DIVISION
Robertshaw-Fulton Controls Company
Milford, Connecticut

FOR BULLETIN F104 CIRCLE 21 ON READER-SERVICE CARD



MELETRON®
Pressure Switch
for Proof Pressures
from 500 to 12,000 p.s.i.

LOW PRICE
Instrument Quality

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS

which, as they wear, cause settings to drift.

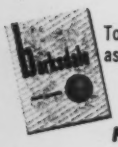
IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it critical to vibration.



To get complete operating characteristics and specifications ask for Catalog 9-PS.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

CIRCLE 22 ON READER-SERVICE CARD

ICS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 35 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1959 THRU MARCH 17, 1960

	High	Low	Price As Of 3/17/60
ACF Industries	57	46 1/4	48
Aeroquip Corp.	40 5/8	23 5/8	34 1/2
Allis Chalmers	40	26 7/8	33 1/8
Amer. Chain & Cable	61 3/4	44 1/4	47 1/2
Amer. Mach. & Foundry	59 7/8	45 1/8	54 1/4
Amer. Mach. & Metals	59 3/4	41	47 1/4
American Optical	53 1/2	38 3/8	46 3/8
Amer. Tel. & Tel.	89 7/8	75 1/8	86 5/8
Ampex Corp (new)	42 1/4	32 5/8	37 7/8
Bausch & Lomb Optical	43 7/8	27	35 1/2
Beckman Instruments	78 1/4	36 1/4	69
Bell & Howell (new)	50	37 5/8	45
Bendix Aviation	89	61	69 1/4
Boeing Airplane	46 1/2	24 3/4	26 1/4
Bullard	24 7/8	13 1/8	15
Bulova Watch	20 5/8	13 3/8	15 5/8
Burroughs	45 3/4	28 3/4	30 1/8
Carborundum	56 3/4	37 3/8	45 3/8
Cinn. Milling Machine	47 5/8	34 1/4	35 1/4
Clevite	59 1/4	24 3/4	48
Columbia Broadcasting Sys.	48 3/4	35	37 3/8
Consol. Electronics	58 7/8	37 1/4	47 5/8
Cornell Dubilier	30 1/2	17 3/4	23
Corning Glass	154	89 3/4	140
Curtiss Wright	40 3/4	20 5/8	21 1/8
Cutler-Hammer	96	59 1/2	84 5/8
Daystrom	49 3/4	34	40
Douglas Aircraft	59 3/4	36 1/4	36 3/4
Eastman Kodak	112	75	102 3/4
Eaton Mfg.	46 7/8	36 3/4	38 7/8
Electric Auto-Lite	55 1/2	36 1/4	52 5/8
Elgin Watch	14	9 3/4	12
Emerson Electric (new)	39 3/4	33	37
Food Mach. & Chem.	56 3/8	40	49 1/2
Garrett	54 7/8	38	49 5/8
General Controls	39 1/2	24	25
General Dynamics	66 1/2	42 7/8	44 7/8
General Electric	99 7/8	74	87 1/8
General Instrument	38 3/8	16 1/2	26 3/8
General Mills	37 5/8	26 3/4	28 5/8
Gen. Precision Equip.	60	31 1/2	50
Gen. Railway Signal	39 1/4	26 3/4	31 1/8
Gen. Tel. & Elect.	85 1/2	60	74
General Time	120 1/2	35	108 3/4
General Tire & Rubber	86 3/4	44 1/8	45 5/8
International Bus. Mach.	488	385 1/2	423
Internat'l. Tel. & Tel.	45 1/2	28	35 5/8
I-T-E Circuit Breaker	50 1/2	30 1/8	31 1/2
Lear Inc.	23 1/4	9 1/8	16 1/8
Litton Industries	75	57 5/8	68 3/4
Lockheed Aircraft	39 3/4	24 5/8	26 3/8
Magnavox	40 3/8	31 3/4	36 1/2
Mallory	50 7/8	35 3/4	41 5/8
Minneapolis-Honeywell	150	111 1/2	137 1/4
Minnesota Mining & Mfg.	186 3/4	111 1/2	176 1/2
Motorola	177	57 1/2	159 1/2
National Acme	63 1/2	49 1/4	49 3/4
National Cash Register	80	55 1/8	58 1/4
Neptune Meter	39 5/8	27 1/2	28 3/8
North American Aviation	52 5/8	30 1/4	34 3/8
Northrop Aircraft	44 3/4	24 5/8	28
Otis Elevator (new)	42	36 3/4	39
Philco Corp.	36 3/4	21	34 1/8
Radio Corp. of America	73 1/4	43 1/8	66 5/8
Raytheon Mfg.	73 7/8	41 1/4	46 3/8
Reliance Electric	73	42 5/8	54 1/4
Rheem Mfg.	30 1/8	17 3/4	22 1/4
Robertshaw Fulton	59 3/4	31 5/8	49 1/2
Royal McBee	24 3/8	16	18 3/8
Sangamo Electric	51 1/2	35	42 7/8
Siegler Corp.	45 1/8	23 1/8	36 1/2
Sperry Rand	28 1/4	21 1/8	22 5/8
Square D	37 7/8	26 7/8	30 1/2
Standard Coil Products	23 3/4	12 3/4	14 1/4
Starrett (L.S.)	23 7/8	18	18
Steward-Warner	33	24 5/8	25 1/4
Telautograph	13 3/8	8	8 1/4-8 3/4(1)
Texas Instruments	193 1/2	61 1/4	171 1/4
Thompson-Ramo-Wooldridge	70 1/4	46 7/8	54
Tung-Sol Electric	54 1/4	32 1/2	35 3/4
Underwood Corp.	32 3/8	19 1/8	28 3/8
Union Carbide Corp.	150 1/2	120 1/2	132 1/2
United Shoe Machinery	65 1/4	45 5/8	53 1/2
Varian Associates	53	26 3/4	46
Wallace & Tiernan	52 7/8	36 1/4	44
Western Union	57	29 3/4	49 3/4
Westinghouse Air Brake	38 1/2	26 3/8	29
Westinghouse Electric (new)	57 1/4	45 1/2	50 1/2
Worthington Corp.	84 1/2	50 1/2	54 1/2

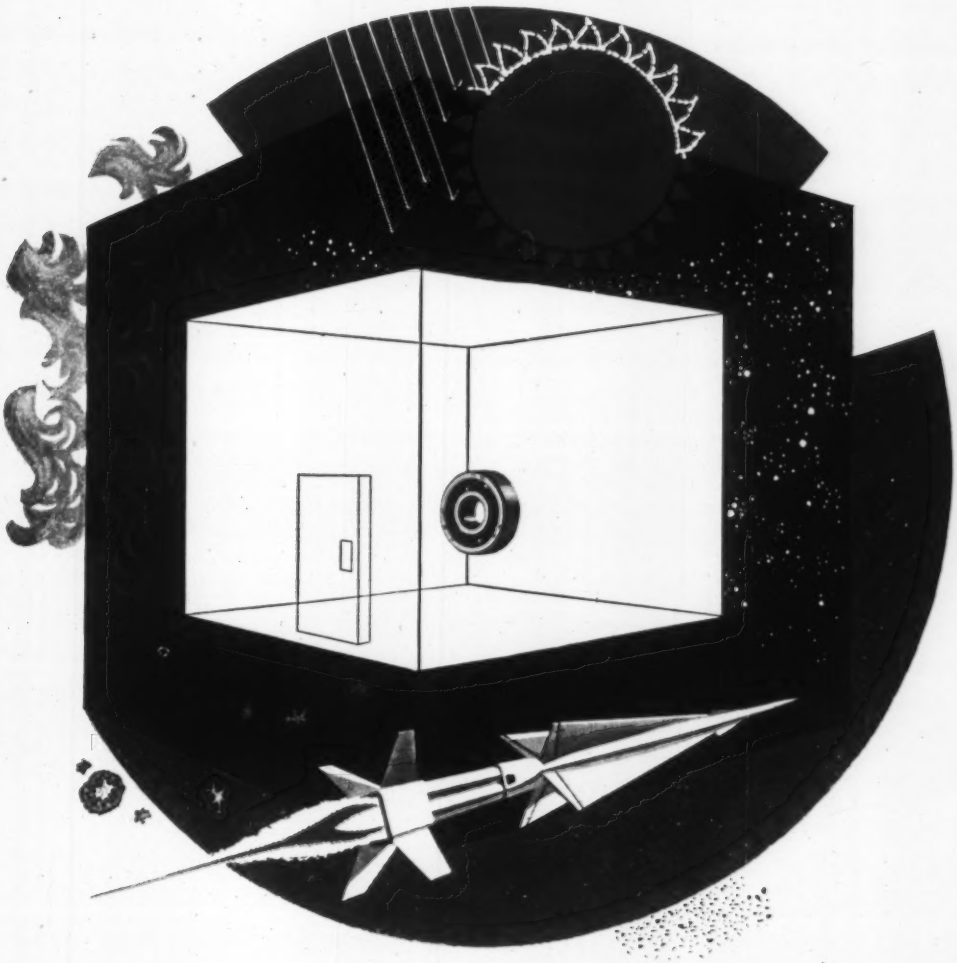
(1) Not traded - Bid and Asked

These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1959 THRU MARCH 17, 1960

	High	Low	Price As Of 3/17/60
American Meter	52	38	45 3/4
Aro Equipment	29 3/4	20 3/4	21 7/8
Barry Controls "B"	26	13 3/4	19
Belock Instruments	22 7/8	10 3/8	17 1/4
Benrus Watch	9	5 1/2	5 5/8
Breeze Corp.	9 3/8	6 1/8	6 3/4
Clark Controller	30 3/8	19 5/8	22 1/8
Clarostat Mfg.	17 1/2	4	13
Clary Corp.	10 7/8	5 3/4	8 1/2
Cubic Corp.	65 5/8	29	52
Du Mont Laboratories	9 7/8	6	7
Dynamics Corp. of Amer.	13 3/4	4 5/8	11 7/8



THOR
MACE
TITAN
HAWK
ATLAS
SNARK
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
VANGUARD
REDSTONE
JUPITER C
PERSHING
BULL PUP
MERCURY
TERRIER
POLARIS
TARTAR
CORVUS
FALCON

N/D's Unique "White Rooms" Improve Miniature Ball Bearing Reliability!

In these rooms infinitesimal air-borne contaminants are scientifically whisked from the air . . . away from super-precision miniature ball bearing parts. New Departure's White Rooms date back nearly twenty years. And today, they're a major factor in N/D's growing recognition as a leader in M/I ball bearing reliability.

At N/D, miniature ball bearings are completely assembled in properly humidified, temperature controlled atmospheres. Advanced air filter systems completely change the air in these spotless rooms every few minutes. In addition, pressurized access air locks and individual counter-top pressurized chambers are used by N/D's skilled technicians during final assembly and statistical inspections.

These methods and equipment are only a few of the reasons why more and more major missile contractors, today, rely on New Departure Miniature and Instrument ball bearings.

If you are working on a new miniature ball bearing application where reliability is critical, include an N/D Sales Engineer in your design discussions. Call or write Department L.S., New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

MINIATURE & INSTRUMENT BALL BEARINGS

proved reliability you can build around

CIRCLE 23 ON READER-SERVICE CARD

For Accurate TEMPERATURE RECORDS at MODERATE COST

RANGES AVAILABLE
Temperature Range
One Rotation of Chart
−30° to +120°F. 7 Days
−30° to +120°F. 24 Hours
−30° to + 50°F. 24 Hours
−20° to + 40°F. 7 Days
−10° to + 50°F. 24 Hours
−10° to + 50°F. 24 Hours
10° to 90°F. 24 Hours
30° to 60°F. 7 Days
40° to 100°F. 24 Hours
40° to 100°F. 24 Hours
50° to 130°F. 24 Hours
60° to 90°F. 8 Hours
60° to 90°F. 24 Hours
70° to 130°F. 24 Hours
−25° to + 10°C. 24 Hours
5° to 40°C. 24 Hours
tempscribe

Use TEMPSCRIBE Recorders

BULB-TYPE (illustrated)—*For recording temperatures at a distance*
BI-METAL TYPE — *For recording temperatures in surrounding air*

- Portable—easily carried. Can be set on flat surface or hung on wall.
- Spring-wound instrument-type clock: 3 standard movements—8 hours, 24 hours or 7 days.
- Instrument measures 4½" x 5½" x 7½"; uses 4¼" diameter charts.
- Chart graduations easy-to-read; spaced uniformly over full range.
- Pen and its actuating components are in door. Doors are completely interchangeable to convert to any temperature range, or from bi-metal type to bulb-type.

Also available: (1) Interchangeable door with electro-magnetic armature to record running time of motors, burners, solenoid valves, etc. (2) Two-pen doors for recording temperature and electrical operation on same chart.

Write for Leaflets 786 and 872

BACHARACH INDUSTRIAL INSTRUMENT CO.

200 N. BRADDOCK AVE. • PITTSBURGH 8, PA. T-25

CIRCLE 24 ON READER-SERVICE CARD

ICS STOCK REPORT

continued from page 540

El-Tronics	2 1/4	1	1 1/2
Electronics Corp. of Amer.	16 7/8	7 1/2	11 3/8
Fairchild Camera & Instrument	157	110 1/4	124 5/8
General Transistor	45 3/8	20 3/8	23 1/2
Globe-Union	29 1/4	20 1/4	30
Haseltine Corp.	33	23 1/4	25 1/8
International Resistance	25 3/8	7	19 3/4
Loral-Electronics	47 3/4	28 5/8	41 1/2
National Research	39 1/2	15 3/8	18 5/8
New Haven Clock	5 3/8	1 1/2	2 7/8
Nuclear Corp. of Amer.	4 1/4	1 3/4	2 7/8
Philips Electronics, Inc.	50 1/4	23 1/2	(1)32 1/2-32 5/8
Pneumatic Scale	67	32	(1)40 -40 1/2
Polarad Electronics	40 5/8	30 1/2	37 3/8
Servo Corp. of Amer.	43 1/2	14 5/8	17 5/8
Servomechanisms	18 1/4	9	9 1/4
Statham Instruments Inc.	43	23	30 1/4
Txatron Electronics	15 3/4	11 1/4	12
Victoreen Instrument Co.	19 7/8	6 7/8	10 1/2
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 3/4

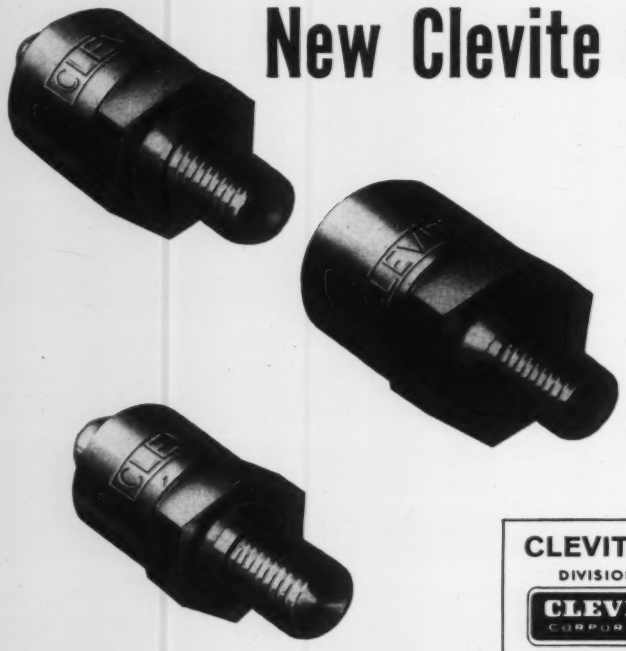
(1) Not Traded - Bid and Asked

These prices and price ranges are given as printed in the Wall Street Journal.

OVER THE COUNTER

	Quotation As of March 16, 1960 Bid	Asked
Aerovox Corp.	12 1/4	12 3/4
Argus Corporation	28 5/8	29 3/8
Black Sivails & Bryson Inc.	16 1/2	17 1/2
Eitel Mc Cullough	27	27 1/4
Electro Instruments	55	56 1/2
Electronics Associates	28 1/2	30
Erie Resistor Corporation	7 1/2	8
Fisher Governor Co.	17	17 1/2
Foxboro Company	75	76 1/2
Giannini Controls	38	39
Hagan Chemicals & Controls	36	37
Industro Transistor	12 1/4	13
Liquidometer Corp.	12	12 3/4
W. L. Maxson	12 3/4	13 1/2
Penn Controls	22	23 1/2
Speer Carbon, Inc.	21 1/4	22
Sprague Electric	55	56 1/2
Taylor Instruments	47	49
Telecomputing Corp.	10 3/4	11 1/8
Vitro Corp. of America	11 1/2	12

New Clevite Accelerometers!



500°F Operation
3% Lateral Sensitivity
50kc 1st Resonance
1600 mmfd. Internal Capacity

Stock Sizes: 5 mv/g
10 mv/g, 20 mv/g

Bulletin 9503 has the details.
Write for it today.

CLEVITE ELECTRONIC COMPONENTS
DIVISION OF
CLEVITE CORPORATION
3405 Perkins Avenue
Cleveland 14, Ohio

FIELD OFFICES
3402 West Century Boulevard, Inglewood 2, California
1915 North Harlem Avenue, Chicago 35, Illinois
60 Franklin Street, East Orange, New Jersey

CIRCLE 25 ON READER-SERVICE CARD

IMPERIAL
Engineering and Data File

DURA-TITE TABLE OF COMPARISON

Features	TYPE OF PORT SEAL		
	Pipe Thread	"O" Ring	Dura-Tite
Permits angular positioning of fitting with no possibility of leaking	no	yes	yes
Suitable for use with all hydraulic fluids without changing components	yes	no	yes
Safety from seepage up to 20,000 psi	no	no	yes
Can be reconnected repeatedly without changing sealing element	no	no	yes
Withstands high pressures to temperatures of 300° F	no	no	yes
Simple to install — no loose parts	yes	no	yes
Usable with SAE standard straight thread boss	no	yes	yes
Unlimited shelf life	yes	no	yes
No deterioration of sealing element due to aging	yes	no	yes
No possibility of damaging sealing element in assembly	yes	no	yes

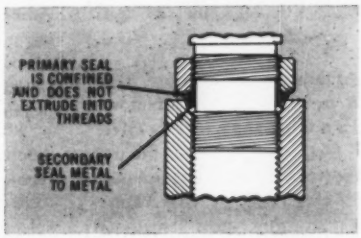
HOLDS PRESSURES TO 20,000 PSI...

NEW DURA-TITE IS INDUSTRY'S MOST FOOLPROOF PORT SEAL FOR TUBE FITTINGS!

From Imperial research comes a new, more effective and far more simplified port sealing method for tube fittings. As you can see on the chart pictured above, Dura-Tite does everything an "O" ring fitting will do—*and much more*—without requiring any special skill or care.

Even at pressures up to 20,000 psi, Dura-Tite provides a positively seepproof seal, and the fitting can be positioned in any direction without impairing tightness. And, because Dura-Tite's polyamide split ring seal is confined, it cannot distort or extrude into threads. The joint can be opened and remade at least 25 times without seepage.

Note how Dura-Tite creates a *double seal* with a single, simple operation. The fitting comes complete, with no additional parts to be added in the field. It uses any standard SAE straight-thread port. No special machining is required.



The special polyamide sealing medium contained in Dura-Tite will outperform any "O" ring compound. It has no hydraulic fluid limitations, being highly resistant to most chemicals. Solves temperature problems, too. Tests have shown that the Dura-Tite seal will withstand high pressures at temperatures up to 300° F. There is no need for periodic replacement because of deterioration on the job.

Dura-Tite port seals can be obtained in both Imperial Hi-Seal flareless and 37° flared tube fittings in steel and stainless steel. And, Dura-Tite costs no more than "O" ring seals but makes important savings in installation.

IT'S IN THE BOOK

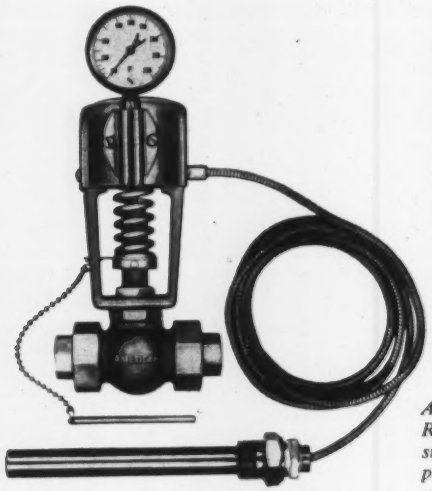
Dura-Tite port seals are covered in Imperial's new Hi-Seal catalog No. 3108 and in Bulletin EPR-2. Send for copies today.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. ICS-40, 6300 West Howard Street
Chicago 48, Illinois

CIRCLE 26 ON READER-SERVICE CARD

immediate

AMERICAN TEMPERATURE REGULATORS begin corrective action with less than 1/10 degree change at the bulb



American Temperature Regulators are made in sizes ½" to 4". Temperature ranges as low as minus 15° F. to 50° F.—as high as 240° F. to 350° F.

response

You get fastest possible temperature response from these new regulators because the stem cannot bind and retard valve action.

The valve stem on American Temperature Regulators is sealed off by a friction-free bellows that makes practical a nonleaking packless valve. Also contributing to fast, stable action is the use of an extra-long preflexed adjusting spring. This spring permits a long range of temperature adjustment without disturbing valve sensitivity at normal levels.

There are other high-quality features in American Temperature Regulators: maximum use of stainless steel; standardized parts; the fewest possible components; and unitized assembly. In addition, compactness simplifies installation in "tight" locations.

Accurate temperature regulation and attention-free operation mean long-term economy. Your industrial supply distributor will gladly help you select the right American Temperature Regulators for your needs. Write for Bulletin 114A.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

AMERICAN TEMPERATURE REGULATORS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 27 ON READER-SERVICE CARD

some leaks don't make drops

the all-new CI LEAKMETER doesn't depend upon catching drops in the measurement of hydraulic or fuel leakage!

The CI LEAKMETER, *when installed in a line between a pressure source and the system or component under test, automatically detects and signals the existence of a leak. It automatically measures and indicates the amount of the leakage. A red light signals the presence of a leak –the amount of leakage is indicated on an electrical meter. The* LEAKMETER *incorporates a timer which can be set for test durations of 15 seconds to 5 minutes, providing a range for the instrument of 0.008cc to 80cc per minute. To measure other rates of leakage, or to test for sustained zero leakage, the timer may be overridden and the test conducted for any desired period.*

The LEAKMETER consists of an Hydraulic Assembly and an Electrical Assembly. These may be installed together, or at separate locations in the test area. Both are designed for rack mounting. Hydraulic connections are made by quick-disconnect fittings.

The LEAKMETER is compatible with all common hydraulic fluids and fuels. The item under test may be subjected to shock, vibration, or temperature, from which the LEAKMETER remains isolated. The instrument accommodates pressures to 5000 psi. Jacks are provided for recording or other readout.

For Complete Information–or to purchase a LEAKMETER *for Immediate Delivery, Write, Wire, or Phone:*

CONVAIR INSTRUMENTS / CONVAIR, A DIVISION OF GENERAL DYNAMICS CORPORATION

3595 Frontier Street, San Diego, California
ACademy 3-1614

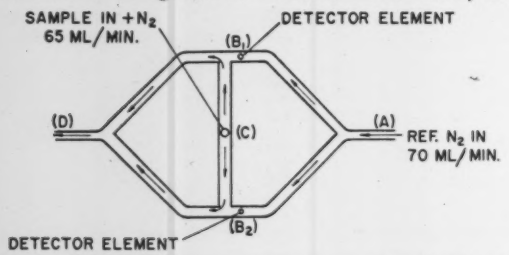
ELECTROMECHANICAL AND MECHANICAL INSTRUMENTS; AC AND DC MEASURING DEVICES, TRANSDUCERS.

CIRCLE 28 ON READER-SERVICE CARD

I&CS BRIEFS

Gas Density Detector

In a pneumatic Wheatstone bridge in vertical plane, reference gas enters at (A) splits into two streams exits at (D) . . . Two, B_1 and B_2 (anemometers) are installed one in each stream, and wired in an electrical Wheatstone Bridge. When the flow is balanced, the

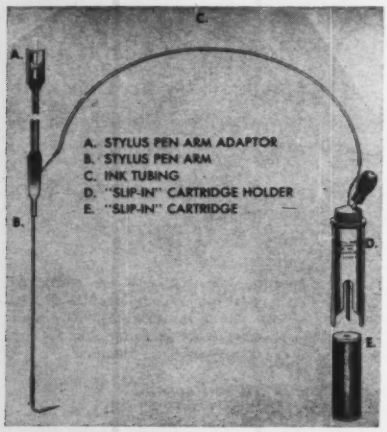


detector elements are equally cooled and the bridge is balanced, thus giving a stable zero trace. The detector elements may be either thermistors or hot wires, depending on the desired operating temperature of the device (boiling point of samples) . . . Sample Gas enters at (C) splits into two streams exits at (D). If sample gas is of same density as reference, there will be no unbalance of reference stream and, consequently, of the detector elements . . . (*From new 2-page Preliminary Specs.* 0129-60, *Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.*

FOR THIS LITERATURE CIRCLE 192 ON READER-SERVICE CARD

Meter Marker

New meter recording marking system with a visible ink supply . . . features . . . "Sli-In" disposable sealed ink cartridges which do the following: (1) Direct handling of ink eliminated, (2) eliminate the problem



on ink contamination, (3) cut out reservoirs; therefore, eliminate cleaning, dust problems, etc., (4) more writing on charts with less trouble . . . (*From new 2-page leaflet Technical Products and Instruments Div., Esterbrook Pen Co., Delaware Ave. & Cooper St., Camden 1, N. J.*)

FOR THIS LITERATURE CIRCLE 193 ON READER-SERVICE CARD

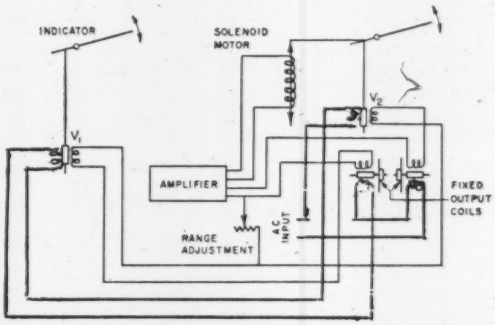
High Speed Printer

The printing system contains the necessary logic to decode incoming digital information and control the printout in a predetermined format. Parallel or serial data entry may be provided with a wide choice of printout characters and/or symbols . . . Solid state electronics is used throughout to enhance reliability and reduce down time. All electronics are contained on modular plug-ins in a logical arrangement to permit tailoring the printer system to the user's requirements at a minimum cost. Speed: Up to 10 lines/sec. Capacity: Up to 17 columns in 20 column format . . . (*From new 2-page Spec. Sheet Series* 3303, *Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, N. Y.*)

FOR THIS LITERATURE CIRCLE 194 ON READER-SERVICE CARD

Transistorized Remote Liquid Level Indicator

The standard Yarway Secondary Indicator is now available in miniature (approximately ¼ size) form . . . The outstanding feature is substitution of a transistorized amplifier. Small sensing coil permits Yarway primary indicator (or Yarway differential-pressure transmitter) to operate the similarly equipped secondary instrument. Primary-secondary circuit con-



tains one sensing coil in primary, three in secondary. Two of the coils in secondary are adjusted for fixed output to permit accurate zeroing of instruments. Movable cores (armatures) in other two coils produce variable output and this unbalance creates voltage differential in signal circuit. Transistorized amplifier, using a printed circuit, operates solenoid motor to move pointer to match position of pointer in primary instrument. Slightest change in liquid level is registered by primary unit and corresponding reading is shown immediately on illuminated scale of miniature secondary indicator . . . The transmitter consists of a pressure housing containing the diaphragm mechanism and a weatherproof housing protecting the sensing coil which operates the remote receiver . . . Slight movement of diaphragm, due to change in differential pressure moves the core (armature) of the differential transformer . . . (*From new 2-page Bulletins RI-1825 (59) Supplements A&B, Yarnall-Waring Co., Chestnut Hill, Phila. 18, Pa.*)

FOR THIS LITERATURE CIRCLE 195 ON READER-SERVICE CARD

"Packaged" Protection for Pneumatic Systems

Harry proves the point ● Moisture and calibrated springs ■ Refrigerate for driest air ○

● Wait'll I Wipe My Glasses!

Harry here doesn't want to *move!* He's not *functioning* properly. He has "condensation frustration." Harmless to humans but the *leading killer* of pneumatic systems.

Cold lenses started it for Harry. In pneumatic systems, the warm saturated air cooling to room temperature fogs the inside of your air lines just like Harry's glasses. Once these contaminants reach your delicate instruments and controls, "condensation frustration" sets in. Your expensive control system acts just the way Harry does . . . slow, uncertain movements, confused responses. The end is always costly . . . system failure perhaps . . . or equipment damage . . . downtime . . . product loss in process plants.

Harry solves his problem by cleaning his lenses. To clean up your pneumatic control system and prevent "condensation frustration", we recommend the economical Hankison Condensifilter or the versatile, all-new Refrigifilter "packages", depending upon your requirements. Use the convenient coupon for more info on either . . . or both!

■ What Price Calibration?

At right are the apparent villains of a mechanical tragedy—with a plot all too familiar to industry. The picture shows two calibrated springs, true heroes of a pneumatic control system until they ran afoul of the real villains — moisture and sludge in the compressed air lines. Result? A fine set of precision springs ruined. Worse, failure of a well-engineered pneumatic control set-up with consequent malfunction of operating equipment.

Prevention could have been simple. A Hankison Condensifilter used to filter and dehydrate compressed air downstream of the receiver would have saved the springs, eliminated downtime and costly repairs. The owners of these springs are now using Hankison Condensifilters — a fact that fellow instrument engineers would do well to remember. Look into Bulletin 4158 describing Condensifilters.

○ Cold Drying Coolest, Man

The neighborhood beatnik would say that if he knew anything about compressed air. Experts on pneumatics simply say that the best air cleaning and drying is done by *mechanical* means, and that the best mechanical method is *refrigeration.* And *we* say, and we're ready to prove it, that the Hankison Refrigifilter is the best refrigeration method.

Why? Well, it's a completely integrated ASME Coded "package" combining the functions of a filter, separator, condenser, heat exchanger, and automatic trap. It has a closed-loop refrigeration cycle to obtain −10°F to −30°F atmospheric dew points. And it does all this without need for coolant water and without regard to ambient temperature variance.

That's why the Refrigifilter was voted one of the top twenty products at the ISA Show last Fall. Write for Bulletin F-100, or use the convenient coupon below.

Hankison Corporation
College & Pike
Canonsburg, Pa.

"Packaged" protection for our pneumatic system interests me. Please send more information on

☐ Condensifilters ☐ Refrigifilters

NAME

TITLE

COMPANY

STREET

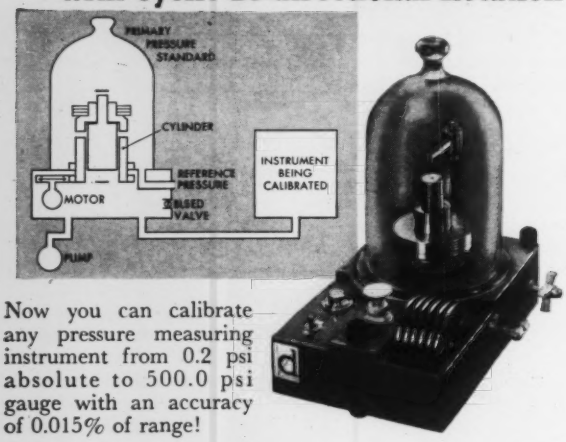
CITY ZONE

STATE

Hankison

FOR CONDENSIFILTERS CIRCLE 29 ON READER-SERVICE CARD
FOR REFRIGIFILTERS CIRCLE 30 ON READER-SERVICE CARD

NEW! PRIMARY PRESSURE STANDARD with Cyclic Bi-directional Rotation



Now you can calibrate any pressure measuring instrument from 0.2 psi absolute to 500.0 psi gauge with an accuracy of 0.015% of range!

- Exclusive cyclic bi-directional rotation of cylinder minimizes lift error
- Four pressure ranges
- Use any reference pressure from zero to one atmosphere absolute
- Self-contained pressure source provides pressure up to 15 psi

Write for Technical Bulletin on Primary Pressure Standard.

DYNAMETRICS CORPORATION

Northwest Industrial Park, Dept. 10, Burlington, Mass.

CIRCLE 31 ON READER-SERVICE CARD

MARSHALLTOWN

DIAPHRAGM GAUGE FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

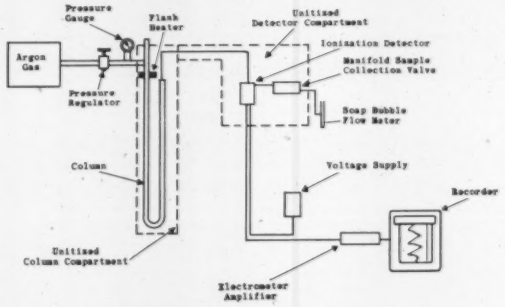
MARSHALLTOWN MFG. COMPANY

MARSHALLTOWN 3, IOWA

CIRCLE 32 ON READER-SERVICE CARD

Gas Detection System

It had been noted that under certain conditions the introduction of minute impurities in the form of a gas or an organic vapor into an ionization chamber containing a small radioactive source and a flowing stream of helium, argon, or neon, greatly increased the ionization current produced by a moderately high voltage applied between electrodes in the chamber. This phenomenon is caused by the presence of highly excited, but non-ionized atoms (metastable atoms) in the carrier gas which attain this state primarily from energy imparted to the electrons in the ionized carrier gas by the electric field between electrodes. Upon collision with the molecules of contaminating vapors in the ionization chamber these metastable atoms transfer their excitation energy to the molecules of the impurity . . . The energy present in the atoms which are in the metastable state is expressed in terms of electron volts . . . Since the ionization potential of many of the organic compounds and gases which are usually analyzed by gas-liquid or gas solid chromatography is

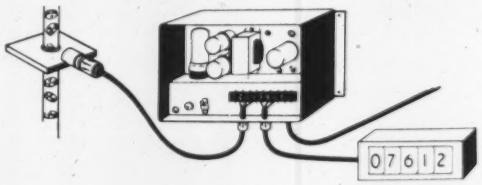


below that of the metastable excitation potential of argon, transfer of energy occurs and large increases in ionization current are readily produced . . . The sensitivity of the Model 10 is such that it can provide full scale recorder deflection for as little as 1 part component in 2 x 10^8 parts of carrier gas when used with a column providing adequate resolution . . . (*From new 10-page Brochure F-9304 Barber-Colman Co., Wheelco Instruments Div., Rockford, Ill.*)

FOR THIS LITERATURE CIRCLE 196 ON READER-SERVICE CARD

Proximity Systems

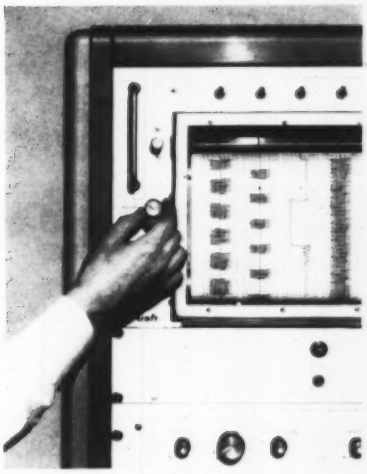
A Proximity System is a device capable of sensing metals (magnetic or non-magnetic) without actual physical contact . . . Various types of sensing elements are available, either in the form of a flat plate, probe like configuration, or a hollow coil thru which parts to

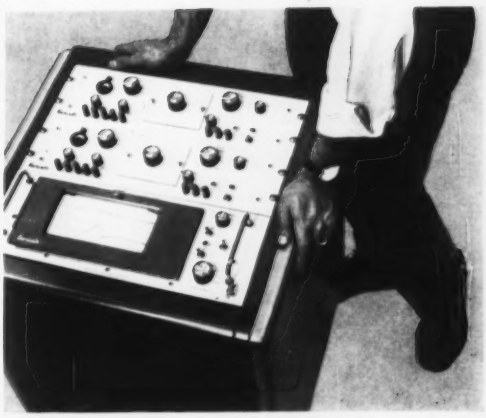


be sensed pass . . . (*From new 25-page Catalog E200 of products made by Electro Products Labs., Artcraft Electric Supply Co., 208 W. 4th St., Wilmington, Del.*)

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

CIRCLE 33 ON READER-SERVICE CARD →





in direct

writing

systems

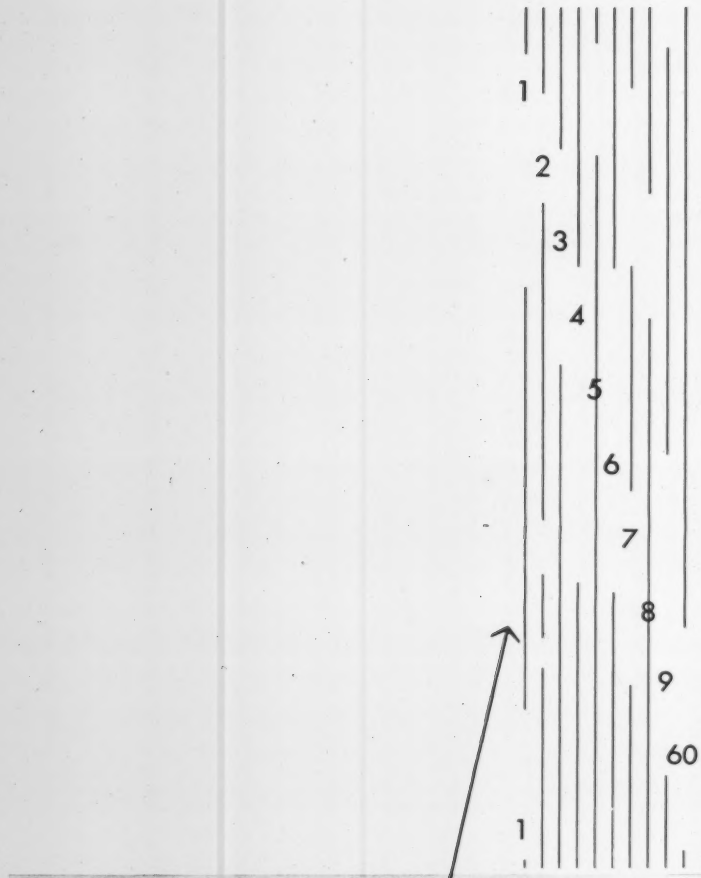
only Brush eliminates compromise

Avoid a "second best" choice. Get exactly what you need. Only Brush permits selection of . . . **Writing Method** . . . ink, electric or thermal . . . **Trace Presentation** . . . curvilinear or rectilinear . . . **Configuration** . . . vertical or horizontal, rack mounted or portable models. Also . . . chart speeds from 50″/sec to 10″/day . . . functionally designed control panels . . . readily accessible components for fast inspection, simple adjustment . . . complete, easy to understand operating manuals. Get the industry's most advanced design concepts. You never need compromise when you specify Brush. Complete information at your request.

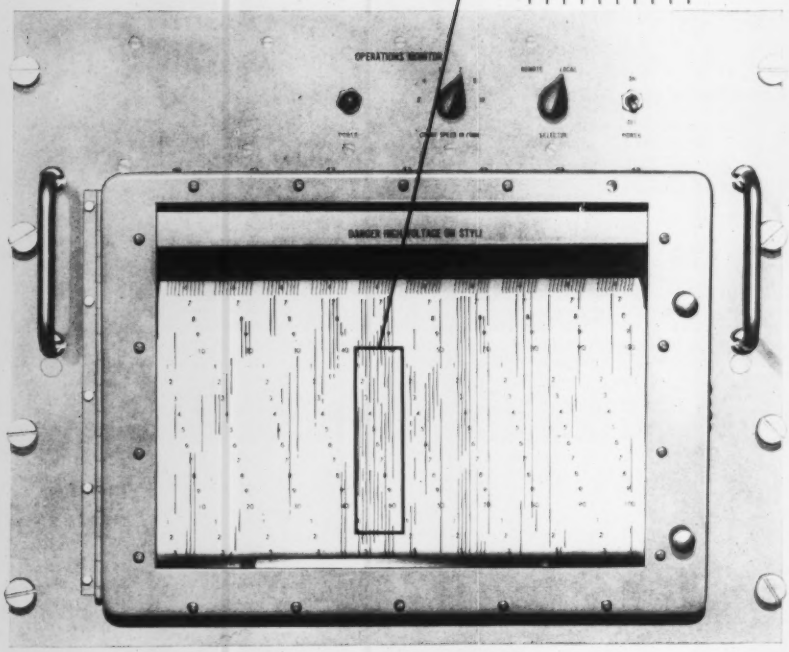
brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO



insight at 4 milliseconds

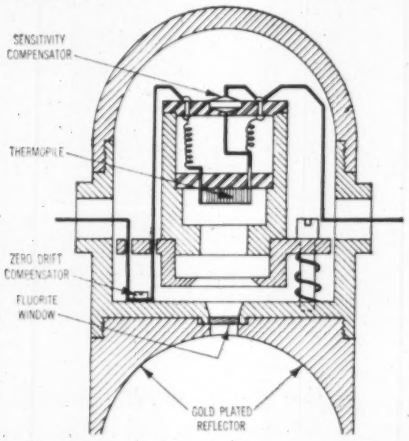


recorded with Brush operations monitors. Multiple high-speed events are reported in writing within 4 milliseconds of occurrence—to establish the basis for split-second, million dollar decisions necessary in today's complex control systems. Up to 120 separate "on-off" event signals are monitored and permanently recorded on a chart only 12" wide. Fixed-stylus electric writing provides sharp, reproducible traces of uniform clarity. Chart speeds from one to 250 mm/sec permit a precise interpretation of all events, with resolution up to 500 signal changes per second. For military or industrial analysis and control, no direct writing recording system can match the capabilities of Brush Operations Monitors. Write today for complete specifications and application data.

brush INSTRUMENTS
DIVISION OF
CLEVITE CORPORATION
37TH AND PERKINS CLEVELAND 14, OHIO

Portable Surface Pyrometer

Different materials (or even two different surfaces made of the same materials) do not radiate the same amount of energy when they are at the same temperature . . . This relative ability of various materials to radiate energy is termed "emissivity" and is expressed as a number which ranges from 1.0 for theoretically perfect radiators down to very nearly zero for bright metals . . .

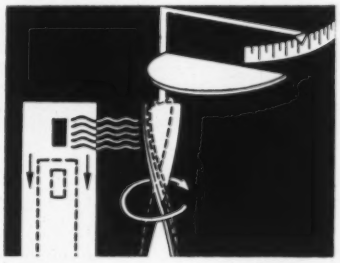


With the Atlantic Surface Pyrometer (Type SP) the emissivity error is reduced to a negligible amount by making the surface at the point of temperature measurement behave almost like a perfect radiator with emissivity of 1.0. The basic principle is that within an enclosed space at uniform temperature, all bodies emit radiation identical to that of a blackbody having emissivity of 1.0 . . . (*From new 4-page Bulletin* 0051, *Atlantic Pyrometers, Inc.*, 190 *Warburton Ave., Hawthorne, N. J.*)

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

Magnetic Position Converter

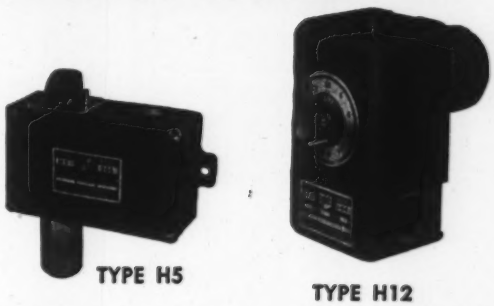
The Magnetic Position Converter translates linear motion of the float into a rotary motion that makes it possible to indicate, transmit, or integrate flow rates. Consists of the magnetic float extension and a helix contained in a non-magnetic tube. The magnet in



the float extension attracts the leading edge of the helix. As the float extension moves vertically the magnetic attraction causes the helix to rotate. An indicating pointer rotates with the helix, providing indication independent of other functions . . . (*From new 6-page Bulletin* 110 *"Graphic Rotameter Selector Aid," Brooks Rotameter Co., Hatfield, Penna.*)

FOR THIS LITERATURE CIRCLE 199 ON READER-SERVICE CARD

External Adjustment & Calibration on
PRESSURE & VACUUM CONTROLS H5 H12



TYPE H5 **TYPE H12**

UNITED ELECTRIC designed these controls for industrial applications where outside adjustment and calibration are important factors. Types H5 and H12 accurately and sensitively control liquid level alarms and air gas pressures. The type H5 (minimum 2 psi differential) controls up to a maximum of 500 psi, and the type H12 (minimum 3" wc differential) up to 180 psi. Uncalibrated, internally adjusted versions of these controls are available as type J7 and type J6 respectively.

Switch Differential	H5 — Uniform on-off differential, fixed from 2 psi to 30 psi. H12 — Uniform on-off differential, fixed from 3" wc to 2 psi.
Switch Ratings	15 amps. at 115 or 230 volts AC, also 20 amps. or DC switches on specification.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Size & Weight	H5 — 5⅛" x 4⅞" x 1½" . . . weighs approx. 1 lb. H12 — ¾" x 2¾" x 5" weighs approx. 1 lb. 6 oz.
Electrical Connection	Conduit opening in enclosure — ⅞" O.D. Internally-located terminal block.
Enclosure	Die-cast aluminum case with black wrinkle finish.
Mounting	H5 — Directly, by ¼" female NPT on bellows housing; or surface mounted by mounting ears on each end of case. H12 — Directly, by ¼" female NPT on bellows housing.
Bellows	H5 — Spring loaded, seamless brass, stainless steel or monel. H12 — Spring loaded, seamless brass bellows.
Pressure Connections	¼" female NPT.

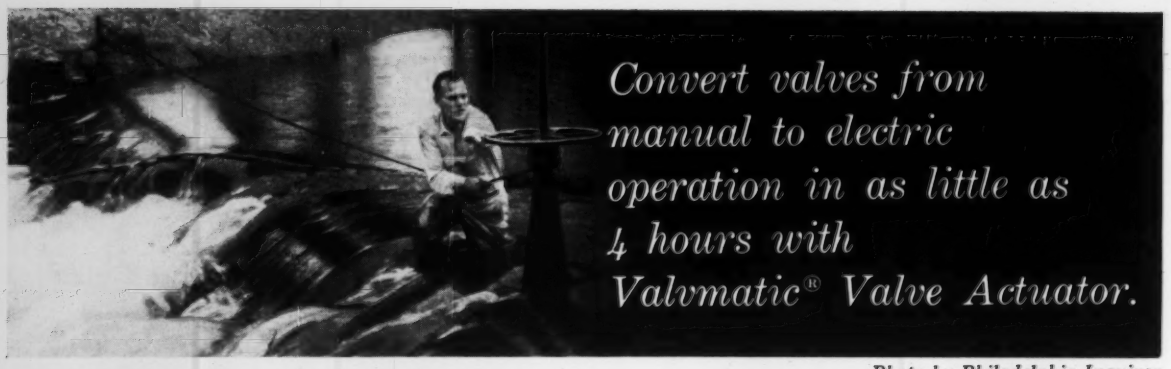
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. UE will gladly modify or custom-build a unit to meet your specifications. Consult a UE application engineer today.*

Write for Bulletin No. 5-5 for complete H5 data and Bulletin No. 5-2 for complete H12 data.

U.E. United Electric Controls COMPANY
80 SCHOOL STREET WATERTOWN, MASS

BULLETIN 5-5 CIRCLE 35 ON READER-SERVICE CARD
BULLETIN 5-2 CIRCLE 36 ON READER-SERVICE CARD

← **CIRCLE 34 ON READER-SERVICE CARD**



Convert valves from manual to electric operation in as little as 4 hours with Valvmatic® Valve Actuator.

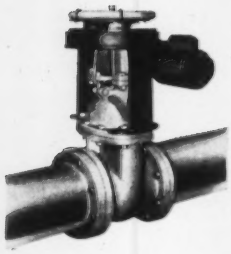
Photo by Philadelphia Inquirer

Now you can eliminate hand operation of hard-to-turn or remotely located valves with economical, easy-to-install Valvmatic.

- No special engineering or special tools
- No disturbance of piping or adjustment of valve
- No downtime of the system
- No replacing of existing valves
- No special wiring

Low initial cost. Minimum installation cost. Valvmatic converts either existing or new valves to push-button locally or remotely controlled operation. Suited also to automated or microwave applications.

High torque, instantly reversible motor, either totally enclosed or explosion-proof. Torque and position control for both directions of operation. If power fails, valve can be restored to manual operation in a few seconds. Performance tested by leading industries.



Write for Catalog V-200 today!

C. H. Wheeler Manufacturing Co.

19th and Lehigh Avenue, Philadelphia 32, Pa.

WV-148

CIRCLE 179 ON READER-SERVICE CARD

MODEL HA 150R
A 60 kV unit is also available.

NEW CARL ZEISS High Voltage Supply Unit

with built-in electronic stabilizer. 150 *kV D.C.*
Made in West Germany

This new unit embodies the most advanced features and offers important advantages in research and technical fields. It can be used for: High voltage supply for electron-optical examinations . . . Examinations of structure by means of electron diffraction . . . Deflecting voltage for particle accelerators . . . High voltage source for neutron generators . . . Electric testing of materials . . . Electrostatic spraying . . . Electronic sorting . . . High voltage supply during lectures, etc.

A safety device is incorporated to protect the operator against being subjected to dangerous high-voltage discharges. The unit is free of disturbing high-frequency radiation, and has only small interfering magnetic fields. Line voltage fluctuations of ±10% have practically no influence upon output. Mounted on casters —easily movable.

Write for literature.

COMPLETE SERVICE FACILITIES

CARL ZEISS, INC.

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CIRCLE 37 ON READER-SERVICE CARD

CIRCLE 38 ON READER-SERVICE CARD →

prevents galling
prevents seizing
protects valuable equipment

GOOP is the amazing new compound for ending the costly galling, seizing and resultant destruction of threaded parts.

The line includes three separate products: Blue GOOP, Silver GOOP and High Purity GOOP.

Silver Goop® is formulated to prevent seizing and galling of threaded parts, regardless of applied load, at temperatures up to 2100° F. It reduces take-up torque on threaded parts. Will not drip off red-hot surfaces nor give off poisonous metal or oxide fumes at high temperatures. Resists water washout.

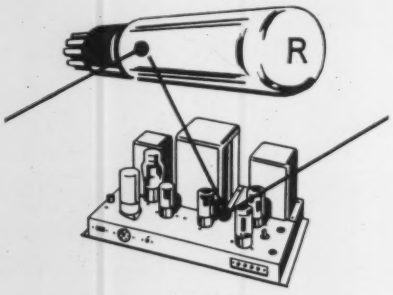
Blue Goop® is an anti-seize and sealing compound for use on titanium, stainless steel, steel, aluminum and high temperature alloys. Withstands temperatures up to 400° F. Impervious to water washout; most acids and all petroleum solvents.

High Purity Goop® is an anti-seize and sealing compound for titanium, stainless steel, steel, aluminum and high temperature alloys. Withstands temperatures up to 400° F. Impervious to moisture, high voltage and cyclic thermal stress. Recommended for use wherever prevention of product contamination is an important factor.

CRAWFORD FITTING COMPANY
884 East 140th Street
Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

Electronic Translation of Computer Language

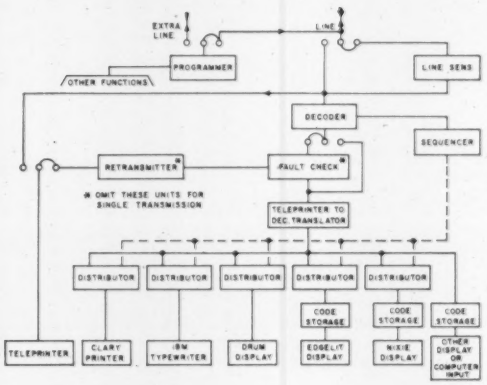
Steps which make up DACOM (DAtascope Computer Output Microfilmer): (1) Computer—signal to tape unit . . . (2) Magnetic Tape Unit plays back the magnetic tape as received from the computer . . . (3) Decoder translates "bits," and combinations of "bits," into impulses which are used to represent the characters we understand . . . (4) Monoscope Tubes—Actually, this is a bank of 60 tubes. Each one represents an alphabetic, numeric or special character, such as plus and minus, in any language required. If more symbols are needed, additional banks of monoscopes are easily added. . . (5) Video Amplifier—The signal from a gated monoscope tube passes to the V.A. where it is "strengthened" for use by the cathode ray display tube . . . (6) Cathode Ray Tube. The characters are flashed to the face of the cathode ray tube . . . (*From new 4-page Bulletin A-1001, Recordak Corp., 415 Madison Ave., New York 17, N. Y.*)



FOR THIS LITERATURE CIRCLE 202 ON READER-SERVICE CARD

Data Transmission System

The Datransyst system uses standard teleprinter code for its transmission. As a result, the incoming information can be fed directly to a teleprinter which will then present "logging" type of display. Other types of display can also be provided . . .

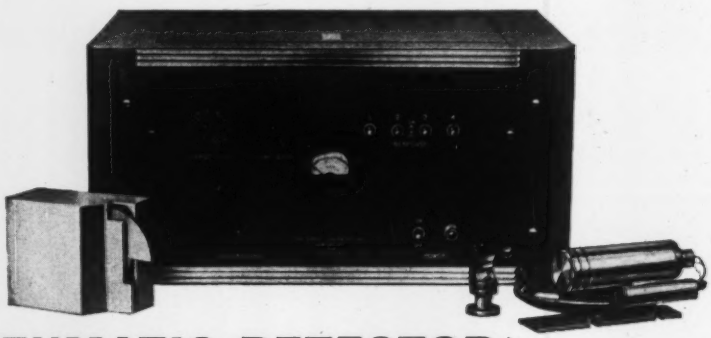


The Datransyst system accepts data presented as "digits" or "characters" in digital form, converts them to start-stop teleprinter code, and transmits them sequentially over telegraph circuits . . .

When a Datransyst receiver is used, the received information may be displayed on Drum dials, Edgelit displays, Nixie tubes, or similar devices, or it may be used to close contacts controlling other devices . . . (*From new 4-page bulletin, Northeast Electronics Corp., Airport Rd., Concord, N. H.*)

FOR THIS LITERATURE CIRCLE 203 ON READER-SERVICE CARD

A Superior Detector for Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR*

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infra-red spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMS-ENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the microwave region.**
4. **Improved, drift-free. A. C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin No. 10

*Fundamental and experimental aspects of this detector are discussed in the following publications: Rev. Sci. Inst. *18*, 347 and 357 ('47); ibid. *20*, 816 ('49); Proc. IRE *40*, 1161 ('52).

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
2 Sheffield Ave. • Newport • Rhode Island • U.S.A.

278-8

CIRCLE 39 ON READER-SERVICE CARD

Skydyne Inc

TRANSIT CASES
MINIMUM WEIGHT
MAXIMUM STRENGTH

"SET" FOR SERVICE

ON LAND — SEA — AIR

Electronic equipment for ground support of missile or conventional artillery . . . field radar . . . tracking systems . . . test systems . . . reconnaissance . . . communications **must** be in instant operating order . . . whenever and wherever required.

These units . . in a combined operational and transportation enclosure by Skydyne . . withstand the hazards of transportation . . . shock, vibration, weather conditions, dust, sand . . . because the "package" is scientifically engineered for **both** equipment and service . . designed and built by Skydyne, and backed by over twenty years experience in transit packaging of instruments and equipment for industry and the government.

Skydyne Transit Cases feature

A completely new basic concept of construction for strength, durability and performance, engineered design for maximum protection to meet your system requirements.

When pounds and protection count . . count on Skydyne for transit cases.

Write for complete details

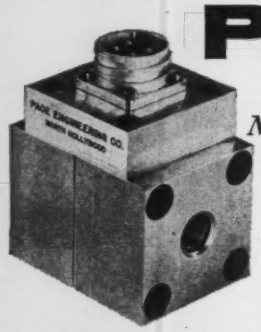
MINIMUM WEIGHT · Skydyne Inc · MAXIMUM STRENGTH

Skydyne Inc
PORT JERVIS, NEW YORK

ALSO AVAILABLE ARE PORTABLE FINGERPRINT EQUIPMENT CA

CIRCLE 40 ON READER-SERVICE CARD

PACE



Magnetic Reluctance

PRESSURE TRANSDUCER MODEL P3D

RANGES AS LOW AS ±1/10 PSID
MAXIMUM LINE PRESSURE 5000 PSI

- **MAXIMUM OVERPRESSURE:** 200 psid or 200% range.
- **EXTREMELY CORROSION RESISTANT.**
- **INSENSITIVE TO SHOCK AND VIBRATION—** not oil filled.
- **ACCEPTS CORROSIVE FLUIDS BOTH SIDES—** all stainless exposure.

Write for your copy of new brochure describing complete line of PACE Transducers.

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CIRCLE 41 ON READER-SERVICE CARD

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- **HARD ALLOY WELDED TIPS**
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CIRCLE 42 ON READER-SERVICE CARD

ICS BRIEFS

Bearing-fixed Valves

Ordinary ball valve floats ball, fixes seat. Floating ball puts excessive pressure load of fixed seats, results in distortion and short life . . . Flo-Ball valve fixes ball, floats seat. Flo-Ball bearings absorb all pressure forces. Elimination of excessive seat loading insures long life . . . Top loading: Valve can be disassembled

	Aluminum	Carbon & Steel	316 S.S.	Buna N	Neoprene	Teflon	Nylon	Kel-F	Viton A
Acetaldehyde			E	U	U	E			
Acetic Acid (Glac., Hot)				U				U	U
Acetic Acid, Pure	E	U	E	G	G	E	E		
Acetic Acid (vapor)									
Acetic Anhydride									

KEY:
E – Especially suitable for use in that fluid.
S – Usually satisfactory where serious conditions are not severe.
G – Gives good service under very mild service conditions.
U – Unsatisfactory.
Blank – Insufficient data.

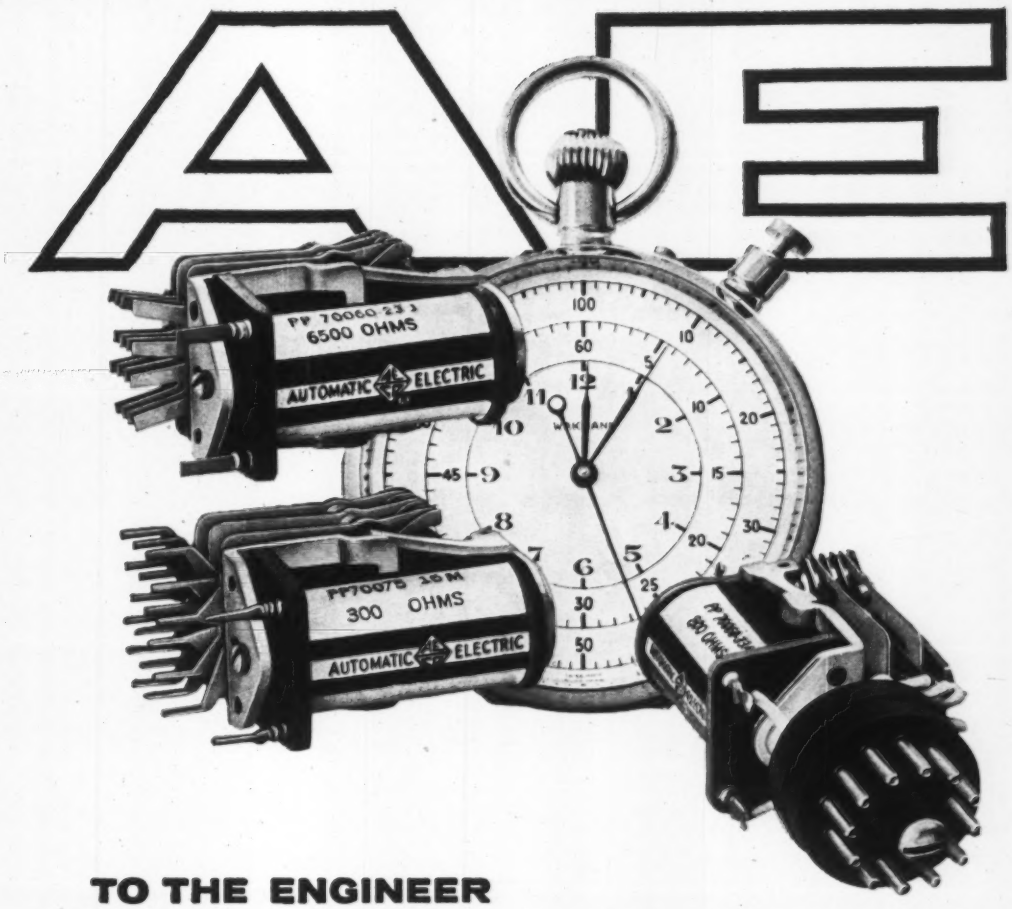
and assembled without removing it from line. No special tools are required . . . No lubrication: Operates completely without lubrication . . . Zero leakage: At all operating pressures, including vacuum to 10^{-6} mm of Hg . . . One-piece stem and ball. Simplified construction adds strength, precision and lower torque . . . (*From new 4-page bulletin "Totally New," and 8-page "Corrosion Resistance Rating Guide," Hydromatics, Inc., Livingston, N. J.*)

FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

Vibron Electrometer

The Vibron Electrometer Model 33-B is a vibrating condenser amplifier intended for measurement of small d.c. voltages and currents derived from a high resistance source. It neither generates nor absorbs any current from the component under test, and hence can be used for measurements which are far beyond the capabilities of the conventional d.c. amplifier . . . The Vibron unit itself is a precise DC/AC electromechanical convertor in the form of a vibrating condenser of extremely high stability . . . The Vibron unit is followed by a four-stage conventional a.c. amplifier, the gain of which is stabiilzed by internal a.c. feedback loops. The final stage is transformer coupled to a phase discriminating rectifier circuit which provides a d.c. output to the meter and recorder and also a d.c. feedback voltage which stabilizes the sensitivity. . . (*From new 4-page Bulletin 1033, Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.*)

FOR THIS LITERATURE CIRCLE 205 ON READER-SERVICE CARD



TO THE ENGINEER

looking for a quick connection

Engineers out to cut costs at no expense of reliability can count on dramatic savings in assembly and wiring time by designing around AE Class E relays with quick-connect terminals.

Series EQPC is designed for direct insertion into printed circuits. Series EQTT, with Taper-Tab terminals, provides firm, high-conductivity connections without soldering.

AE also supplies Class E relays prewired for plug-in – with standard 8- to 20-prong octal plugs. Where additional relay protection is essential, the plug-in types are available in hermetically sealed containers or with dust-tight housings and hold-down brackets.

The AE Class E relay is a miniaturized version of the premium-quality Class B, with many of its best features. Perfect contact reliability exceeding 200 million operations is common.

AE is also equipped to supply wired and assembled, custom-built control units, *or to help you develop complete systems.*

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry,* and the new 32-page booklet on *Basic Circuits.*

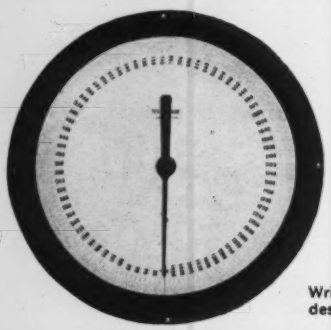
AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

CIRCLE 43 ON READER-SERVICE CARD

PRECISION TEST GAUGES



Designed for the Ultimate in Accurate Pressure Measurement

Write for descriptive brochure M-28A

Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 115 square inches of panel space.
- Ni-Span C Bourdon tube is temperature stable.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

Write For Descriptive Bulletin AS 31

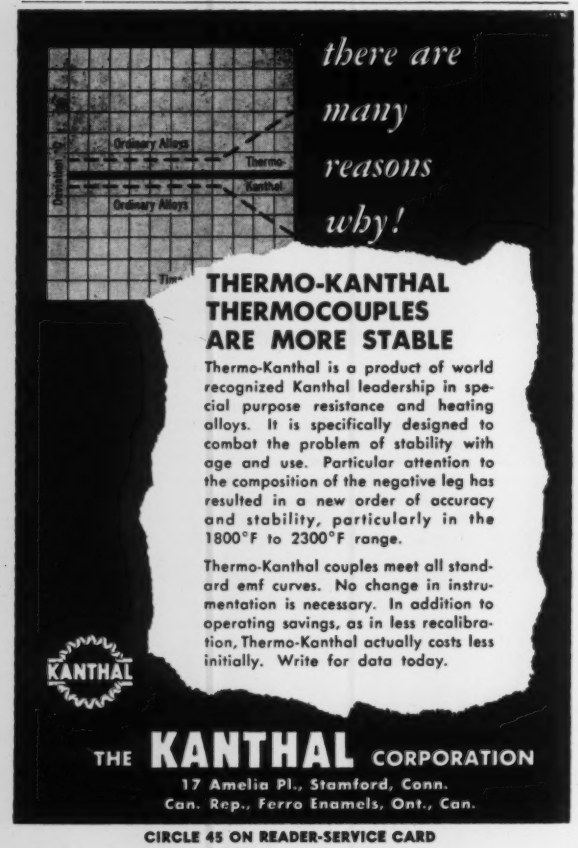
Select territories available to test equipment or gauge distributors. Write direct to C. L. Howard, Industrial Sales Manager.

MARTIN DECKER M/D

Martin-Decker Corporation
3431 Cherry Ave., Long Beach 7, Calif.

Precision Pressure Instruments— Testing — Weighing — Load and Force Measurement

CIRCLE 44 ON READER-SERVICE CARD


there are
many
reasons
why!
Ordinary Alloys
Thermo-
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Ordinary Alloys
THERMO-KANTHAL THERMOCOUPLES ARE MORE STABLE
Thermo-Kanthal is a product of world recognized Kanthal leadership in special purpose resistance and heating alloys. It is specifically designed to combat the problem of stability with age and use. Particular attention to the composition of the negative leg has resulted in a new order of accuracy and stability, particularly in the 1800°F to 2300°F range.
Thermo-Kanthal couples meet all standard emf curves. No change in instrumentation is necessary. In addition to operating savings, as in less recalibration, Thermo-Kanthal actually costs less initially. Write for data today.
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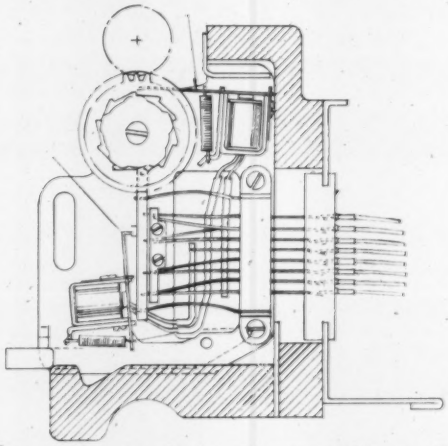
CIRCLE 45 ON READER-SERVICE CARD

Logic Switches

Tally Logic Switches are basically electro-mechanical power amplifiers of pulsed bi-stability with delayed configurations. Each switch includes an extensive complement of switching elements, providing massive logic combinations. Three basic elements are combined in each switch—a delay element, a bi-stable element, and a number of AND gates associated either with the assert or negative side of the bi-stable element . . .



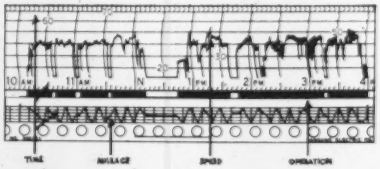
One of the two logic states available in Tally Switches is always present in complete mechanically stable form. That is, power may be removed from the system without change in its logic state. This permanent memory feature is especially useful in pulse delay logic . . . (*From new 8-page Form TRC-LS-2, Tally Register Corp., 5300 14th Ave., N. W., Seattle 7, Wash.*)

FOR THIS LITERATURE CIRCLE 206 ON READER-SERVICE CARD

Tachograph

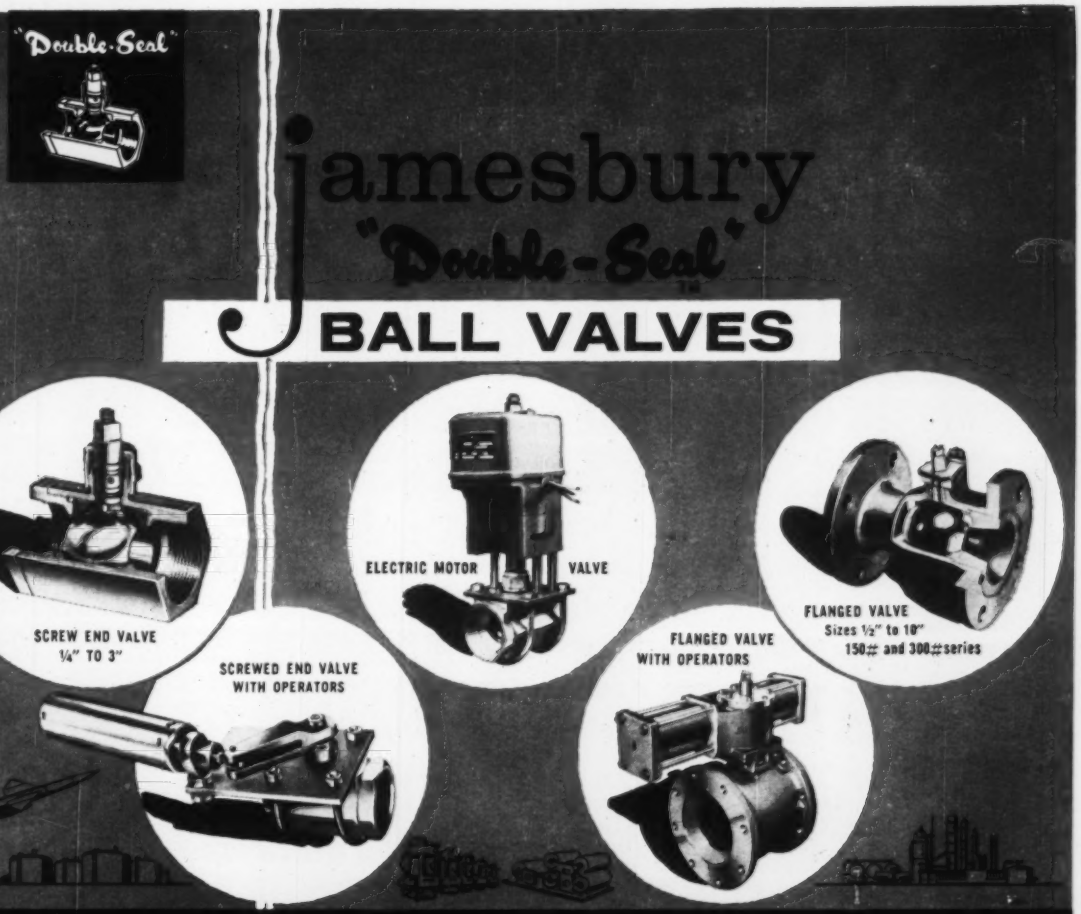
Model EM records trip information in miles per hour, engine operating, idling and off time, and total mileage—all in relation to exact time of day or night. This model is used when the speed of the vehicle as related to the over-all operation is desired by the fleet operator. It is connected to the vehicle's speedometer cable . . .

8 DAY and 15 DAY CHART
(ACTUAL SIZE)



The exact hour and minute of time that a vehicle is stopping, idling, traveling at any given speed, has halted abruptly after an accident, or is 2 or 200 miles from its starting point, can be accurately measured on the outer rim of the chart, in the band showing record of operation or in the portion recording mileage . . . The important, accurate record of speed at any given minute shows how the vehicle was handled . . . (*From new 8-page Bulletin SU-140, Wagner Electric Corp., 6400 Plymouth Ave., St. Louis 33, Mo.*)

FOR THIS LITERATURE CIRCLE 207 ON READER-SERVICE CARD



JAMESBURY BALL VALVES
AS VERSATILE AS INDUSTRY ITSELF!

Throughout industry, wherever you look, you'll find the versatility of the Jamesbury Ball Valve doing a more efficient, more economical job.

In chemicals, paper, rubber, petroleum, aircraft, and missiles, Jamesbury Ball Valves handle a wider range of liquids and gases than any other valve design.

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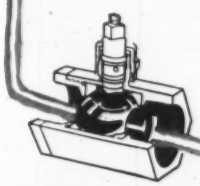
Jamesbury pioneered the "Double-Seal" Ball Valve construction and leads the way today with the latest in ball valve design and applications.

Greatest Range of Sizes and Materials Available

Jamesbury "Double-Seal" Ball Valves are available in 303 and 316 Stainless Steel, Alloy 20, Carbon Steel, Bronze, Ductile Iron, Aluminum and PVC.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.



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HELPING BUILD OUR
NUCLEAR NAVY

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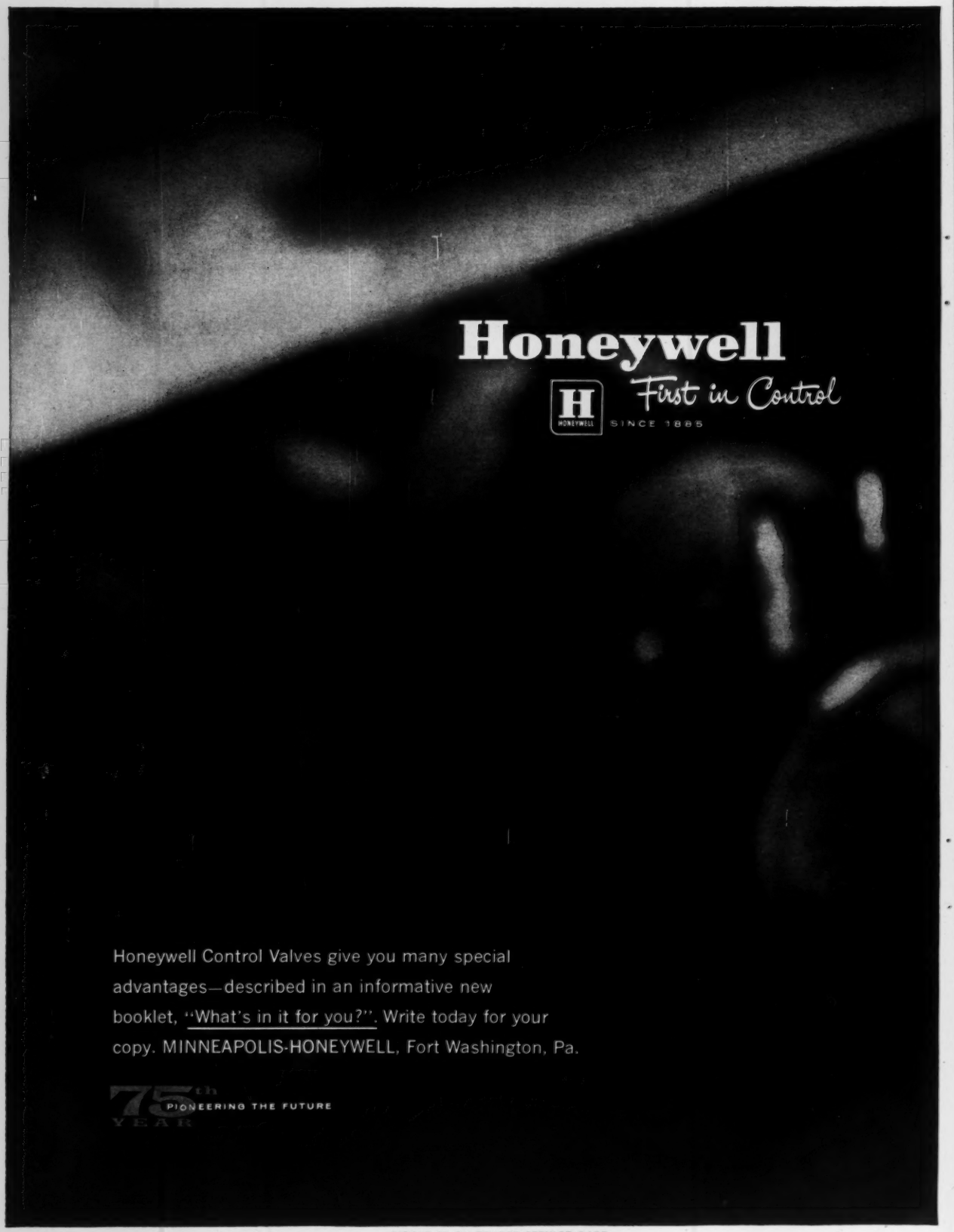
Distributors in Principal Cities

CIRCLE 46 ON READER-SERVICE CARD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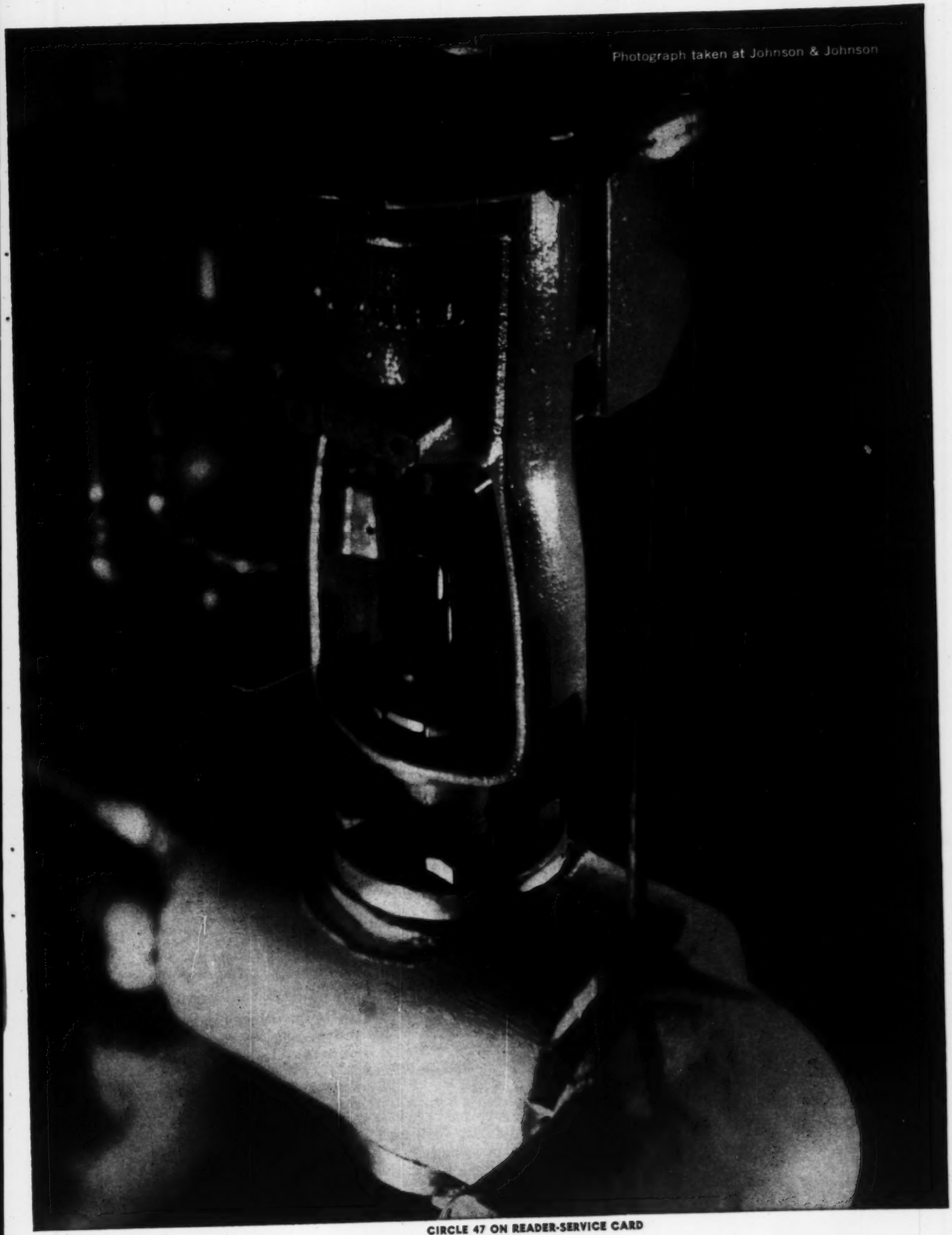
First in Control
SINCE 1885
Honeywell Control Valves give you many special advantages—described in an informative new booklet, "What's in it for you?". Write today for your copy. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE

CIRCLE 47 ON READER-SERVICE CARD



CIRCLE 47 ON READER-SERVICE CARD

CHECKUP on your Control Valves... CHECKOFF these Annin Advantages*

*Any other source might give you a few... but with Annin you get them all!

MINIMUM number of parts per complete valve.

OVER 60,000 successful case histories of split body valve applications.

POSITIONING ACCURACY guaranteed, .001 inch per inch of stroke.

CONSTANT INSTRUMENT signal sensitivity throughout signal range.

COMPLETE INTERCHANGEABILITY of any Domotor valve to on-off pneumatic control, pneumatic hydraulic, electro hydraulic, electro pneumatic or manual actuator.

ENGINEERED FOR MANUAL control with any of the above automatic actuators, if desired, at minimum cost.

SIMPLIFIED ADDITION of high speed booster units to any pneumatic positioning actuator.

ADAPTABILITY of bellows seal, doolseal or plain extension to any standard valve.

BODY SIZES from ¼" up.

COMPLETE LINE of body ratings: 600—1500—2500 lbs. ASA; special 10,000 and 60,000 psig design, temp. —450°F to 1600°F.

CONVERSION FROM globe body to angle body construction with only one additional part.

ADAPTABILITY TO 3-WAY Valve Construction with minimum parts and cost.

MINIMUM COST for change from soft seat construction to hard seat, or vice versa.

First in a series of checklists on Annin features.

Annin VALVES

THE ANNIN COMPANY
1040 South Vail Avenue
Montebello, California

CIRCLE 48 ON READER-SERVICE CARD

PANHANDLE PETE

WESCO!
Personnel Div.
Long Bottom, W. Va.
Attn: *Panhandle Pete*:

I would like to apply for that systems-engineering position advertised in the February issue of *INSTRUMENTS AND CONTROL SYSTEMS*. As my experience has been good in all the fields you mention, (mechanical, electronic, etc.) I am an experienced systems engineer.

Experience in Mechanical Field: I have had three years in mechanical alignment of complex linkages in camber and caster arrangements.

Also specialized on mechanical shaft-plus drag-cup type velocity telemetering and integrating system; also an expert on installing damping-ratio controller for spring-mass inertial systems.

Experience in Pneumatic Field: Four years of pressure testing and air injection of all sizes of vehicular rotational supporting mechanisms (wheels). Also installed pressure switches for emergency annunciator (stop) lights.

Experience in Optical Field: Five years in charge of crew responsible for transparency of multi-laminar vitreous products used as protective shields for operators of vehicular mechanisms. Specialized in maintenance and alignment of directive optical systems with high-power light source and lens using Fresnel optics.

Experience in Hydraulic Field: Three years on hydraulic systems used for velocity control of high-powered vehicles. This included not only hydraulic fluid insertion but complete system from master cylinders to brake lining.

Experience in Electronic Field: Complete check out and selection of frequencies for mobile radio receivers with push-button control of local-oscillator frequency.

Experience in Electrical Field: Several years on maintenance and installation of systems producing high-power pulses for ignition of fuels in internal-combustion engines, including high-speed commutating, pulse development and wave shaping of signals.

Experience in Instrumentation: Have specialized in volumetric flow measurement of petroleum products used for vehicle propulsion, using positive-displacement meters.

Also have great experience in temperature control of cooling media in fluid-heat-sink-type vehicles via bellows-type bimetallic-operated thermoregulators.

Experience in Chemical Field: Am specialist in analysis of freezing points of various solutions, particularly alcohol and ethylene glycol solutions.

Education: Have B.S. and M.A. degree in education and taught for 10 years before leaving teaching and taking present position (in order to increase income).

Please reply at my present place of employment (will do my boss good to know that I looking around).

Robert P. Smith
c/o Joe's Service Station
Long Island, New York

Report for work Monday

Panhandle Pete:

I saw your ad in the February issue of your magazine for an engineer for WESCO!

I think that I am qualified for the position as outlined in the list of qualifications. I am an expert in all the industries listed and even some not listed.

I hold many patents for instruments. In addition I have been successful in executive leadership in several large design and manufacturing businesses. I would like the opportunity to step into the new challenging field of systems engineering.

There is only one drawback. Your ad mentions that the applicant should not be over 30 years of age. I am 31. I would be willing to work for quite a bit less to compensate for the age limit.

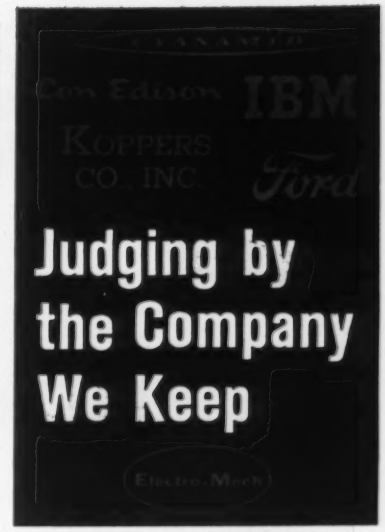
A Reader
General Delivery
Lower Slobovia
(Postmark: Seattle, Wash.)

Report for work Monday

Panhandle Pete:

This is to let you know that I enjoy your column very much, not only for its technical humor, which is sadly lacking in our chemical trade-journals, but also for the insight it gives into the real problems facing the instrument industry. Please keep up the column; I look at it first thing every month.

R. N. Pratt
Claymont, Del.



. . . "the Company We Keep" being the largest to the smallest American Industrial Firms. All are served in the most critical area of modern business activity: the reduction of operating cost and increase of production quality through automation.

Electro-Mech Corporation has a single reason for being—the manufacture of Custom Control Systems for industry. Our customers require that *their* control system be individually tailored to the demands of their particular plant operations. They often request our contribution in the selection of overall control panel design and detailed construction techniques.

Our engineering staff is always available to assist and complement your own Instrument Department personnel. This service is frequently requested in order to implement a tight job schedule or to relieve excessively burdened design and drafting facilities.

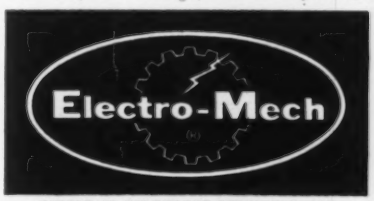
Electro-Mech is the third member of your plant automation team:

1. Your Instrument Department —for engineering
2. Your Instrument Company —for components
3. Electro-Mech Corporation —for manufacturing

Won't you join "the Company We Keep" and serve, with Control Panels by Electro-Mech?

Your quotation requests are invited.

Electro-Mech Corp., Norwood, N. J.



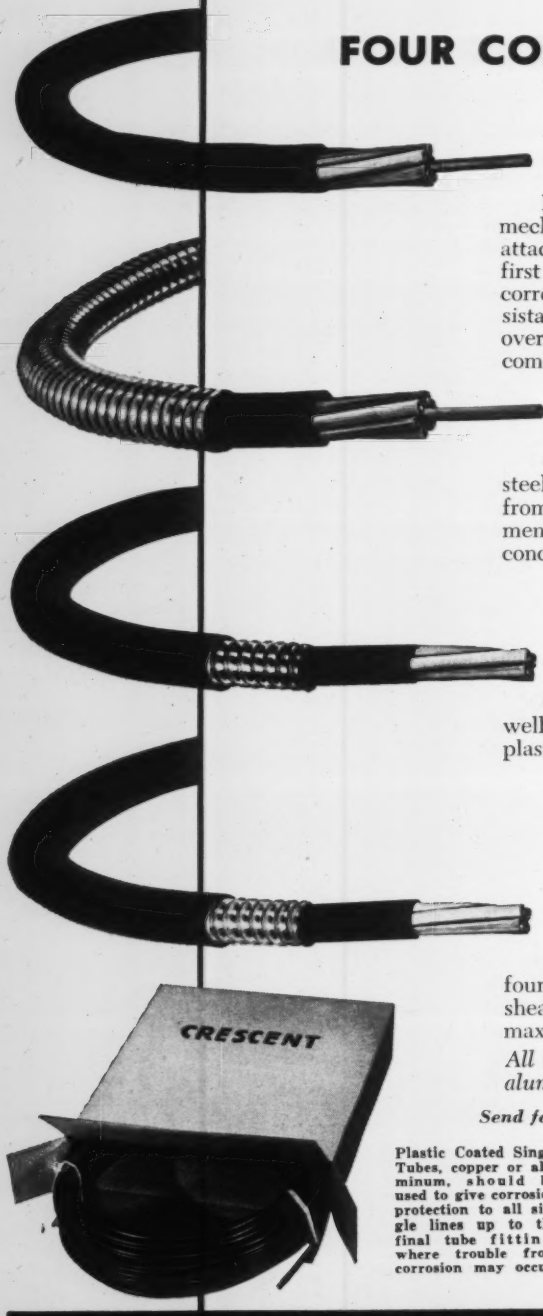
CIRCLE 49 ON READER-SERVICE CARD

The Answer to Your Corrosion Problems

CRESCENT ARMORED MULTITUBE*

*Reg. Trade Mark

FOUR CORROSION-RESISTANT TYPES



TYPE CT

In damp or corrosive locations where a moderate degree of mechanical protection to the tubes is required, as in troughs or attached to sheltered building surfaces as supporting means, the first construction illustrated is recommended. It employs a tough, corrosion-resistant polyvinyl chloride thermoplastic sheath, resistant to water, acids, alkalies, oils and most chemicals, applied over CABLED copper tubes. The sheath will not support combustion.

TYPE CTA

Gives corrosion protection to the tubes, and the galvanized steel armor protects the tubes and polyvinyl thermoplastic sheath from mechanical injury during and after installation. Recommended for direct burial in concrete or pulling into underground conduits.

TYPE CAT

Gives corrosion protection to the galvanized steel armor as well as the tubing. Recommended where the polyvinyl thermoplastic sheath will not be subject to mechanical injury.

TYPE CTAT

Combining the advantages of Types CTA and CAT, the fourth type illustrated has the polyvinyl chloride thermoplastic sheath both under the armor and over the armor, thus providing maximum mechanical and corrosion protection.

All these corrosion-resistant types can be furnished with copper, aluminum and polyethylene tubes, and up to 37 tubes.

Send for Bulletin 458-A giving complete information and engineering data

Plastic Coated Single Tubes, copper or aluminum, should be used to give corrosion protection to all single lines up to the final tube fitting, where trouble from corrosion may occur.

WEST COAST REPRESENTATIVES

AUTOMATION PRODUCTS
120 North Division St.
Spokane 2 Washington
2800 - 15th Ave. West
Seattle 99 Washington
619 S.E. Morrison St.
Portland, Oregon

VAN DYKE VALVE & FITTING CO.
273 27th Street
Oakland 12 California

WARREN & BAILEY COMPANY
3528 S. Garfield Ave.,
Los Angeles 22 Calif.

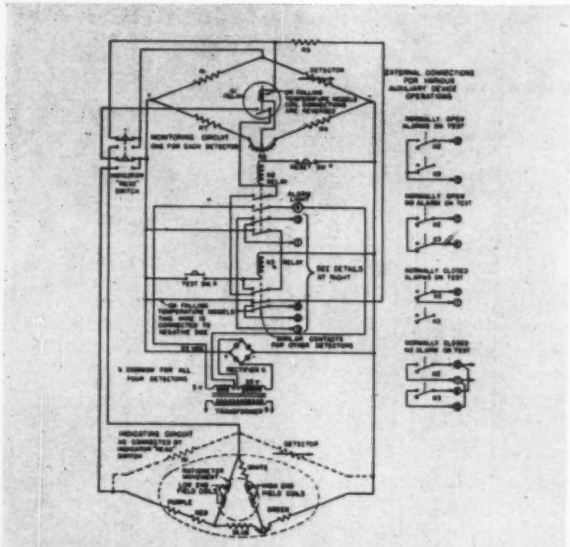
CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

CIRCLE 50 ON READER-SERVICE CARD

Questions and Answers on the **EDISON OMNIGUARD SYSTEM**

The Most Effective Means of Measuring and Safeguarding Temperatures and Pressures



Q. How does the Omniguard System work?

A. Edison's Omniguard is characteristically simple and unique in its operation. Each Omniguard channel is a conventional D-C Wheatstone bridge circuit in which an Edison temperature or pressure detector forms the variable leg of the bridge. As the temperature or pressure rises and falls, the detector resistance increases or decreases. An Edison relay (K1) across the bridge senses the current flowing through it. When conditions are normal the current flows in the direction to hold the relay contacts open. When a variation occurs, however, current flow reverses and the contacts of this alarm relay close. Relay K1 energizes the coil of auxiliary relay K2 which actuates an alarm light on the panel face to show which detector is "off-normal," actuates an external alarm or annunciator and maintains the alarm indefinitely – until conditions have returned to normal and the normally closed reset switch is opened.

Any temperature or pressure can be read at any time by pressing the indicator read switch for that point.

Q. Is Omniguard dependable?

A. Reliability is built in. Since each measuring channel is an independent, separate circuit, complete system failure is unlikely. Only the most reliable components are used. Edison resistance temperature detectors don't "drift" over years of service. There are *no* scanning mechanisms to wear out . . . *no* delicate components . . . *no* electronic circuits . . . *no* amplifiers . . . *no* periodic maintenance requirements.

Q. Is Omniguard flexible?

A. Completely. A system can monitor as few as 4 or as many as hundreds of variables. Buy only what you need. Since channels are independent of one another, each can be set to alarm at a different temperature or pressure. Alarm settings can be changed easily and quickly.

Omniguard can be used for alarm or shut down of equipment, alarm can be local and remote, is easy to telemeter to remote control station.

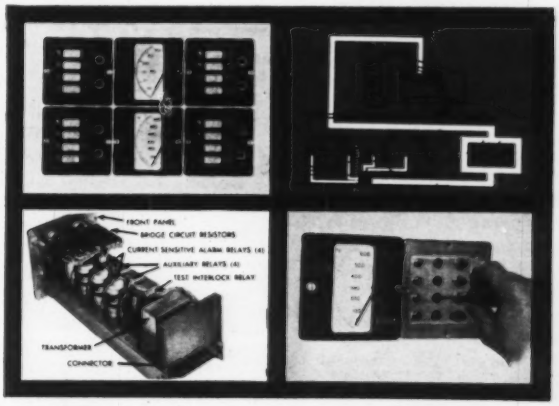
Q. Is Installation economical?

A. Omniguard is the simplest system available. Fewer parts mean lower costs, less maintenance. Plug-in monitors are installed in minutes with no special tools or calibration. Ordinary copper wire connects remote detectors to monitors. Monitor units act as their own annunciators, identify each temperature and pressure, eliminating the need for extra equipment in most installations. Omniguard is a *complete* system with all parts including hardware supplied by Edison.

Q. How accurate are Edison's Resistance Temperature Detectors?

A. In the range from −200°F to +1350°F, no other type of detector is as stable, sensitive, and accurate over years of service. Response times of 0.8 seconds are common – detectors are repeatable to .05% over years of use, resistance being directly proportional to temperature.

Resistance Pressure Detectors are accurate to 1% or better depending on pressure range.



For complete information on the Edison Omniguard System, industry's simplest, most reliable means of continuously monitoring critical temperatures and pressures, write for Bulletin 3036C.

Thomas A. Edison Industries

INSTRUMENT DIVISION

24 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 51 ON READER-SERVICE CARD

ICS BOOKS

Automazione e Salute (Automation and Health) by Giovanni Berlinguer, published by Instituto di Medicina Sociale (Institute of Social Medicine) 1958, 145 p., 9½", paperbound Lire 1500. Medical-social problems of the technological advances are reviewed after an exposition of automation and its applications in Italy and abroad.

CIRCLE 208 ON READER-SERVICE CARD

Bodine Fractional Horsepower Motor Handbook published by Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill., 66 p., 9", paperbound, $1.00. Contains chapters on application fundamentals, economics and special features, care and servicing, and engineering data.

Automatic Titrators, by J. P. Phillips, [c1959] Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 225 p., 9", clothbound, $6.00. Emphasis in this book is on the chemist's approach to the problem rather than that of the physicist and electronic scientist. State of the art is up-to-date through September 1958, while obsolescence in this field in the short thirteen years since its inception is rather great.

CIRCLE 209 ON READER-SERVICE CARD

Economic Control of Interconnected Systems by Leon K. Kirchmayer [c1959] by General Electric, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 207 p., 9", clothbound, $12.50. A companion to the author's previous book "Economic Operation of Power Systems," this volume emphasizes treatment of mathematical methods, computers, and controllers to obtain the optimum economic operation of interconnected electric utility systems.

CIRCLE 210 ON READER-SERVICE CARD

101 Ways to Use Your Audio Test Equipment, by Robert Middleton, [c1959] Howard W. Sams & Co., Inc., 2201 E. 46th St., Indianapolis 6, Ind., 136 p., 8½", paperbound $2.00. Book answers basic questions about audio instruments, omitting general instruments such as VOM's, VTVM's, oscilloscopes, etc.; and audio theory. It is intended as a practical handbook.

CIRCLE 211 ON READER-SERVICE CARD

Digital Computer Primer, by E. M. McCormick [c1959] McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 214 p., 9", clothbound $7.50. An easy-to-understand introduction to computers, explaining operation; potentialities; coding; number systems; logic; the control-arithmetic-, storage-, and input-output units; how to give instructions, to program the computer, and to check its accuracy. Mathematics of logices are treated in appendix.

CIRCLE 212 ON READER-SERVICE CARD

Experiments in Electronics by W. H. Evans [c1959] Prentice-Hall, Inc., Englewood Cliffs, N. J. 374 p., 9", clothbound $6.75. 100 carefully planned experiments form the basis for this book. Two experiments are given on each subject, featuring a wide range of transistor and solid state devices. Includes components list and test equipment lists.

CIRCLE 213 ON READER-SERVICE CARD

Nuclear Power Plant by E. Oppershow Taylor [c1960] Philosophical Library Inc., 15 East Fortieth St., New York 16, N. Y., 184 p., 8½", clothbound $7.50. Book deals with nuclear and reactor physics, types of reactors, reactor engineering, instrumentation and control. Contains comprehensive tables of elements and chronology of nuclear power.

CIRCLE 214 ON READER-SERVICE CARD

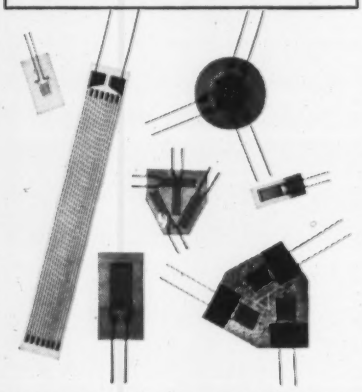
Petroleum Engineering: Drilling and Well Completions by Carl Gatlin, [c1960] Prentice-Hall, Inc., Englewood Cliffs, N. J. 341 p., 11", clothbound $13.00. Written expressly for students, book contains numerous examples, and comprehensive problems are given at the end of each chapter with answers when necessary. Each chapter is accompanied by an extensive bibliography.

CIRCLE 215 ON READER-SERVICE CARD

An Introduction to Electronic Data Processing, by Roger Nett and Stanley A. Hetzler [c1959] The Free Press of Glencoe, Ill., 287 p., 9¼", clothbound $6.75. Volume covers computer research with its technology, technique, economy, etc., aimed at scientists and businessmen who have not yet shared in this development, but are eager to use it.

CIRCLE 216 ON READER-SERVICE CARD

The bonded strain gage makes the difference



SR-4® Transducers and Systems (see opposite page) are used wherever accurate measurement and control of weight, thrust, pressure or torque are required.

Their growing importance on the industrial and military scene is due largely to a unique combination of ruggedness and high accuracy which results from the use of a truly ideal transducer sensing element . . . the SR-4® bonded filament strain gage. This postage-stamp-size device, well known to stress analysts and structural designers as a precision laboratory tool, performs an equally important, and more permanent, function when bonded inside hermetically sealed load cells, pressure cells, and torque pickups.

There it translates minute, force-induced strains into proportional changes in a small electric current flowing through its grid. Detected and amplified, these signals are used to actuate indicators and/or recorders and to control a variety of functions and processes.

Thanks to the bonded strain gage, SR-4® transducers provide advantages unmatched by any other commercially available device.

- High accuracy (to ±0.1% or better)
- Excellent linearity and repeatability
- Rugged construction—no moving parts to wear or maintain
- Hermetically sealed—unaffected by dirt, moisture or corrosive vapor
- Consistent performance, unit to unit
- Infinite resolution
- Maximum flexibility of application and installation

SR-4® Transducers or an SR-4® System may be particularly suited to your requirements. For additional information on weight, pressure, thrust or torque measurement, write Dept. 7-D.

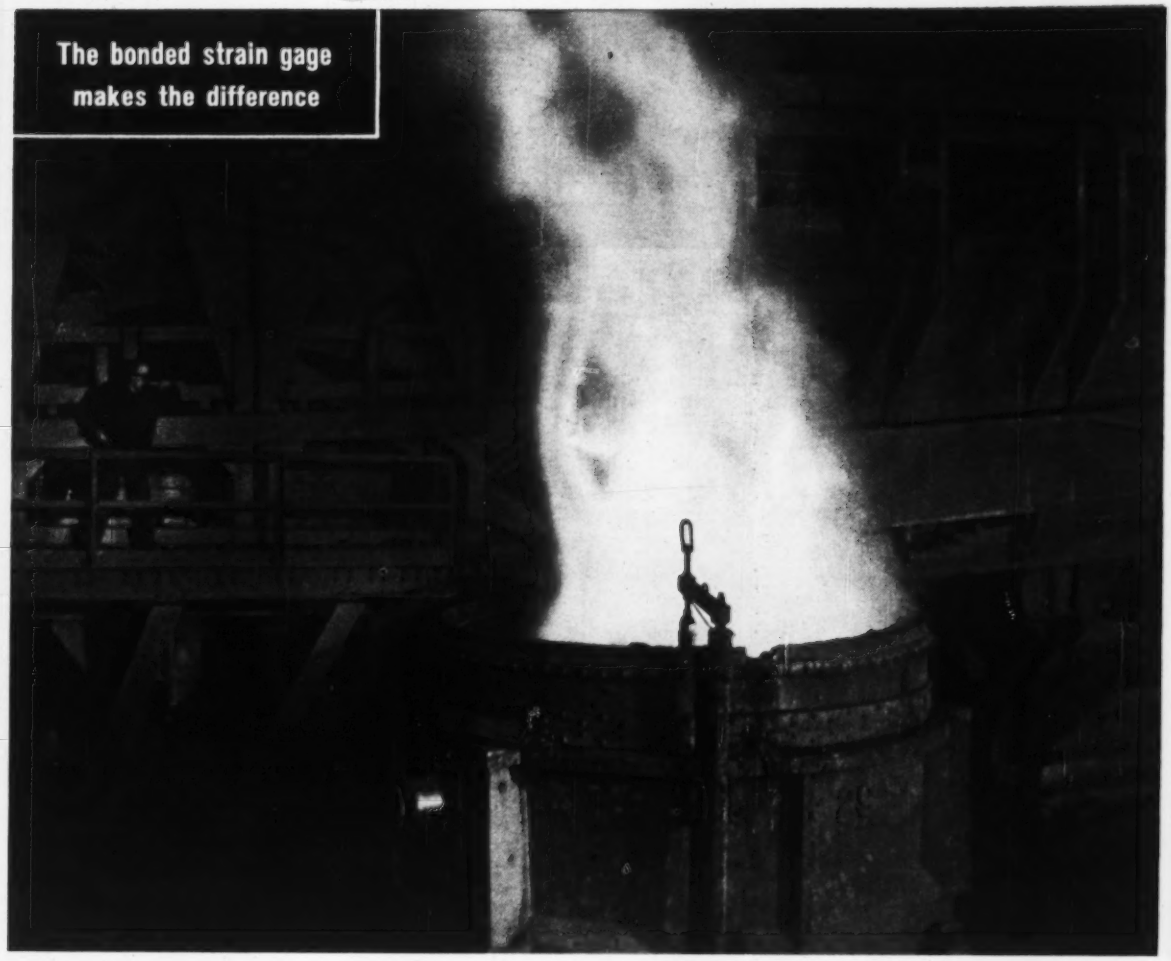
FIRST in force measurement

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division
Waltham, Mass.

SR-4® Strain Gages • Transducers • Systems

CIRCLE 52 ON READER-SERVICE CARD

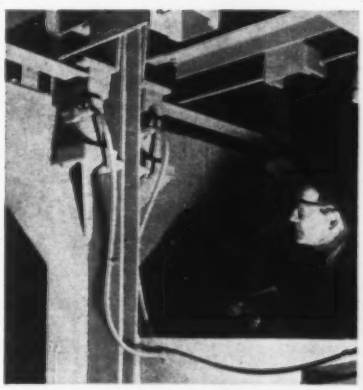


SR-4® system measures ladle additives automatically, helps turn out better ingots

A new means of adding ferro-alloys to steel automatically as it is poured from the ladle is quietly revolutionizing open-hearth steelmaking.

In developing its new Ladle-Additions Feeder, Blaw-Knox engineers turned to Baldwin-Lima-Hamilton for a rugged, accurate weighing system which would operate dependably under conditions where shock, overload and temperature change are the rule rather than the exception. The resulting system, now helping to save production time and improve steel quality in many installations, utilizes four 20,000-lb. SR-4® load cells on each additive bin. They send accurate weight signals to a B-L-H indicating and control system, which automatically feeds additive in precise amounts by weight.

In this, as well as countless other industrial applications, it is the SR-4® bonded strain gage which provides the required accuracy and dependability. Let B-L-H engineers solve your force measurement problems.



Two SR-4® load cells in adjacent bins of a Blaw-Knox Ladle-Additions Feeder. Special B-L-H system filters out vibration and shock signals, sending only precise weight data to instrument panel.

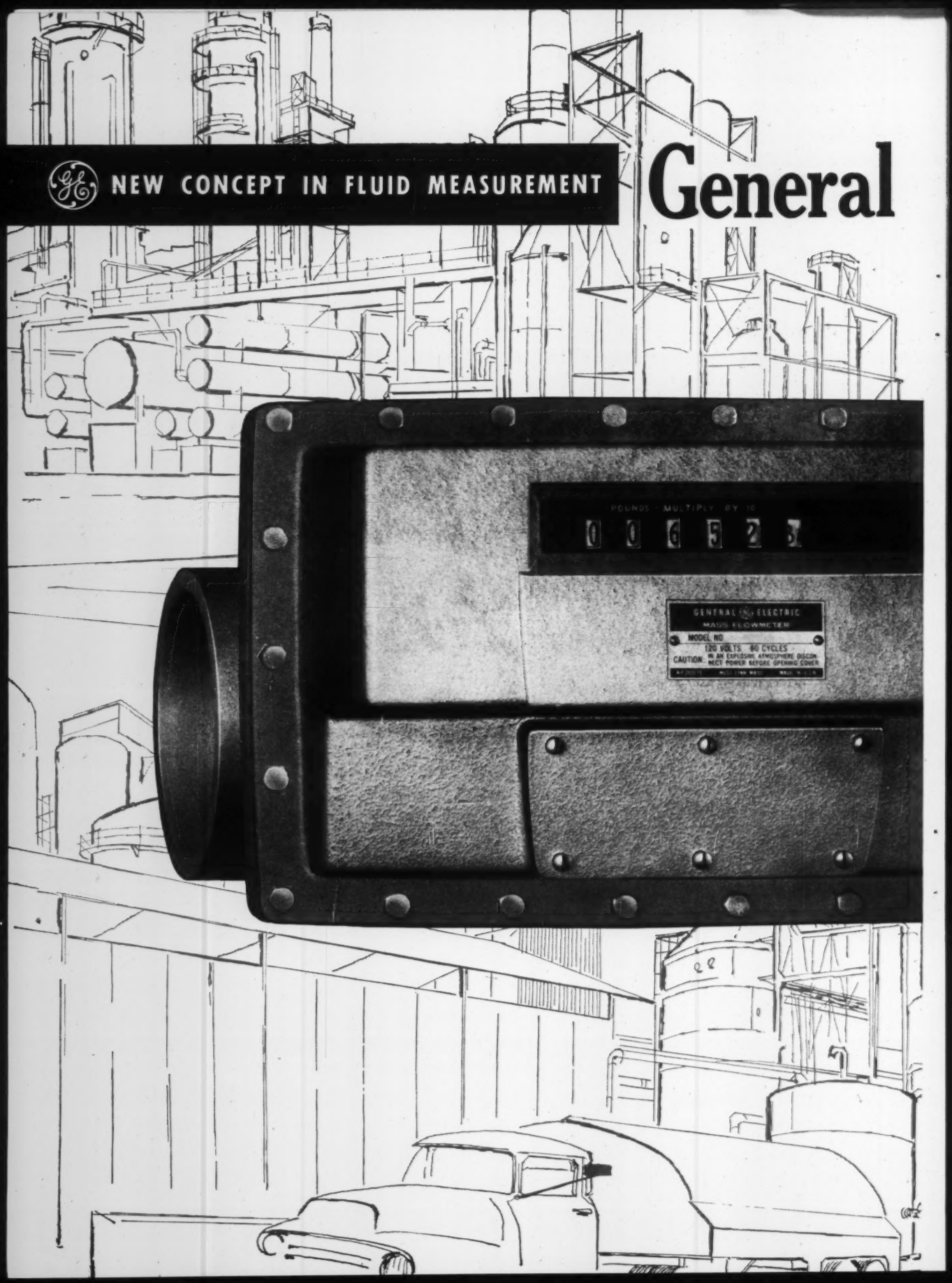
First in force measurement

BALDWIN · LIMA · HAMILTON

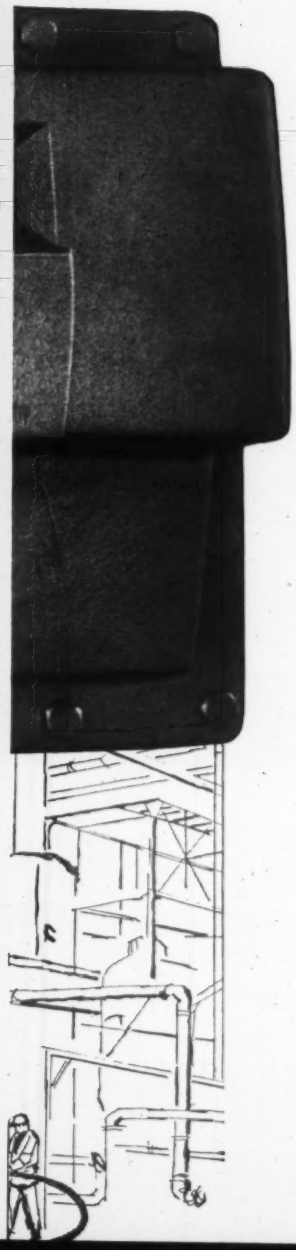
Electronics & Instrumentation Division • Waltham, Mass.

SR-4® Strain Gages • Transducers • Systems

CIRCLE 52 ON READER-SERVICE CARD


NEW CONCEPT IN FLUID MEASUREMENT
General
POUNDS · MULTIPLY BY 10
006523
GENERAL ELECTRIC
MASS FLOWMETER
MODEL NO.
120 VOLTS 60 CYCLES
CAUTION:

Electric Gyro-Integrating True Mass Flowmeter



ACCURATELY MEASURES FLOW OF LIQUIDS, GASES AND LIQUEFIED GASES . . . DIRECTLY IN POUNDS

This new General Electric meter provides continuous local or remote totalization and registration of gas and liquid flow by weight within ±1 percent accuracy over wide variations in flow rate, density, pressure, temperature and viscosity.

PROCESS FLOW MEASUREMENT—Ideal for applications in the petroleum, chemical, and petro-chemical industries, the new mass flowmeter completely eliminates time-consuming orifice calculations and possible costly errors in correcting volumetric readings for fluid variables. It does away with the need for recalibration when process and flow conditions change, too. And it puts an end to supercompressibility problems.

What's more, the new flowmeter lets you make complete and accurate material balances easily because it operates on a mass measurement principle and gives you your answer *in pounds*. No more measuring liquids in gallons or barrels, gases in cubic feet, then making tedious conversions in order to equate the two. Measurement of both by weight allows direct comparison.

LIQUEFIED GAS MEASUREMENT—You can measure the weight of truck and tank car loading of your liquefied gas products easier and faster with General Electric's new mass flowmeter than with present volumetric-type meters or expensive and cumbersome scale installations. The meter registers the total loaded weight directly in pounds. Then, operating from a battery-inverter power supply, the flowmeter can be used right on your truck when unloading, for easy and accurate deliveries. And no precautions are necessary to protect the meter from high velocity caused by "flashing."

An outgrowth of General Electric research into mass flow measurement, this new meter has already been proved on such fluids as natural gas, ethylene, Freon, liquid carbon dioxide, naphtha and jet fuel.

For complete sales and service information, contact your nearby General Electric Apparatus Sales Office, or write for bulletin GEA-6925A, Section 599-02, General Electric Company, Schenectady 5, N. Y. On applications in the natural gas industry, contact Black, Sivalls and Bryson, Inc., Kansas City, Missouri.

FOR QUALITY... PRODUCTIVITY ... PROFIT / INSTRUMENTATION FOR AUTOMATION

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 53 ON READER-SERVICE CARD

WORKING PARTNERS

RCA 501 — SOUNDCRAFT INSTRUMENTATION TAPES

R-96

Big business depends more and more upon electronic data processing. For many corporations, the heart of their data reduction and storage operation will be the new RCA 501 Computer System. The crucial testing period of this new computer called for the most reliable of instrumentation tapes . . . Soundcraft. And, Soundcraft Tape proved to be the perfect working partner—not only in the testing, but afterward, in continuous working use.

In short, experience has proven that Soundcraft works best on leading computer systems, like the RCA 501. Let precision-made, trouble-free, error-free Soundcraft Instrumentation Tapes go to work for you. *Complete literature on request.*

REEVES SOUNDCRAFT CORP. Great Pasture Rd., Danbury, Conn. • Chicago: 28 E. Jackson Blvd. Los Angeles: 342 N. LaBrea • Toronto: 700 Weston Rd.

CIRCLE 54 ON READER-SERVICE CARD

Choose from thousands of Honeywell instruments to measure and control

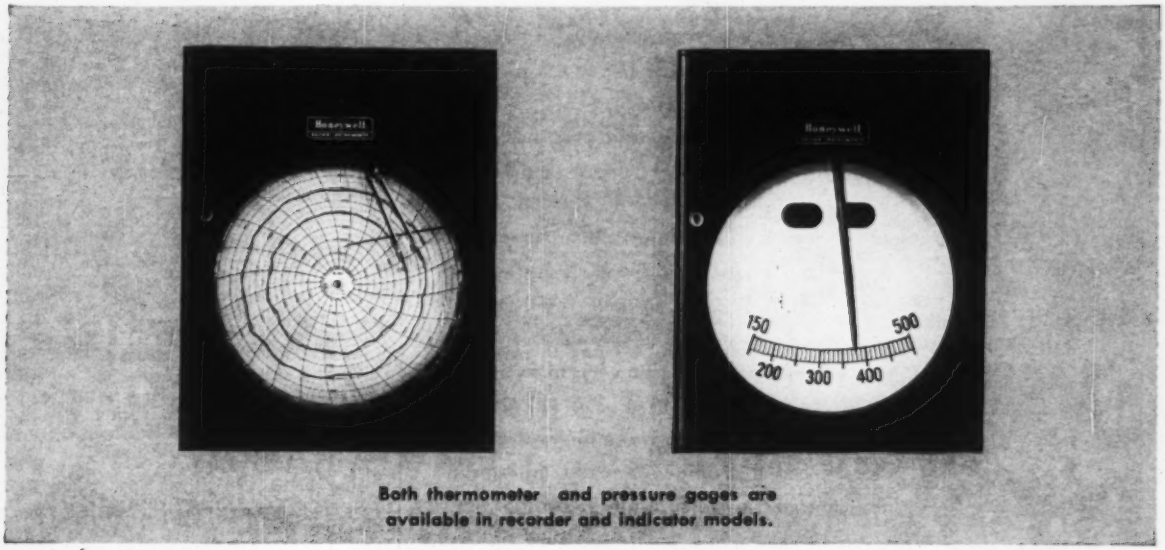
TEMPERATURE and PRESSURE

The enormous variety of options available in Honeywell thermometers and pressure gages gives you custom design in standard instruments. Choose from *thousands* of combinations of pressure and thermal elements, chart and scale ranges, transmitting, receiving and pneumatic or electric control units.

Use Honeywell thermometers to measure temperatures from −125°F to 1000°F, with accuracy of ±1%. Measure pressures as high as 4000 psi and as low as 5 inches of water vacuum with Honeywell pressure gages.

Whatever your requirements in temperature and pressure measurement and control, there's a Honeywell instrument virtually made to order for you. Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



Both thermometer and pressure gages are available in recorder and indicator models.

CONTROL COMBINATIONS AND OPTIONS

TEMPERATURE

Thermal systems—vapor, mercury, or gas actuated, case, case and capillary, or self-compensated.

Bulb styles—plain, union-connected, averaging, preformed capillary, rigid extension, dairy, wet and dry bulb assemblies, self-contained thermal systems.

Electric control—*Electr-O-Vane*, spst (on-off control), spdt (two-position control), sp3t (three-position control).

Pneumatic control—On-Off. 10% *Throttlor* (1 to 10% proportional band, manual reset), *Full Throttlor* (1 to 150% proportional band, manual reset), *Air-O-Line* (1 to 150% proportional band, automatic reset).

PRESSURE

Pressure and vacuum elements—spiral, intermediate-range spring and bellows, low-range spring and bellows, dual spring and bellows for absolute pressure.

Electric control—*Electr-O-Vane*, spst (on-off control), spdt (two-position control), sp3t (three-position control).

Pneumatic control—On-Off. 10% *Throttlor*, *Full Throttlor*, *Air-O-Line*.

75th YEAR PIONEERING THE FUTURE

Honeywell

First in Control

SINCE 1885

CIRCLE 55 ON READER-SERVICE CARD

HEISE GAUGES

IN RANGES UP TO 50,000 psi.

The Heise Gauge, for many years a world standard for precision pressure measurement, is NOW available for use in ranges up to 50,000 psi.

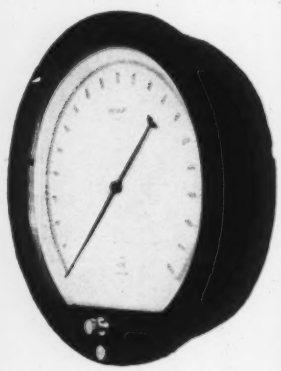
Control of this extreme pressure is made possible by the new Heise heavy duty Bourdon Tube, a single unit which eliminates all internal connections.

The Tube, made from #403 Stainless Steel, is multi-coiled to reduce unit stress and formed to a scientifically precise section by an exclusive Heise process.

Mounted on the Heise integral gauge movement this unique element initiates a new concept in pressure gauge design.

The 50,000 lb. gauge features the traditional high quality workmanship expected of all Heise equipment.

Accuracy is held to 1/10 of 1% of full scale reading in this ultra high pressure laboratory instrument.



PRESSURE RANGES	DIAL SIZES	PRICES	DELIVERY
15 to 50,000 P.S.I.	8½"-12"-16"	from $166.75	within 30 days

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 56 ON READER-SERVICE CARD

ICS EVENTS

May 2-4
NAECON 12th Annual National Aeronautical Electronics Conference, Biltmore and Miami-Pick Hotels, Dayton, Ohio. For information write J. S. Horrigan, 5387 Maple Cliff Ct., Dayton 15, Ohio.

May 3-5
1960 Western Joint Computer Conference, Jack Tar Hotel, San Francisco, Calif. For information write H. M. Zeidler, Stanford Research Institute, Menlo Park, Calif.

May 9-12
Summer Instrument-Automation Conference & Exhibit of I.S.A., Civic Auditorium, San Francisco, Calif. For information write I.S.A., 313 6th Ave., Pittsburgh 22, Penna.

May 9-11
Annual PGMTT Symposium, sponsored by IRE Professional Group on Microwave Theory and Techniques, Hotel del Coronado, Coronado, Calif. For information write David B. Medved, CONVAIR, Division of General Dynamics, Mail Zone 6-172, Box 1950, San Diego 12, Calif.

May 10-12
1960 Electronic Components Conference, sponsored by IRE Professional Group on Component Parts, AIEE, EIA and WEMA, Washington, D.C. For information write IRE, 1 E. 79th St., New York 21, N. Y.

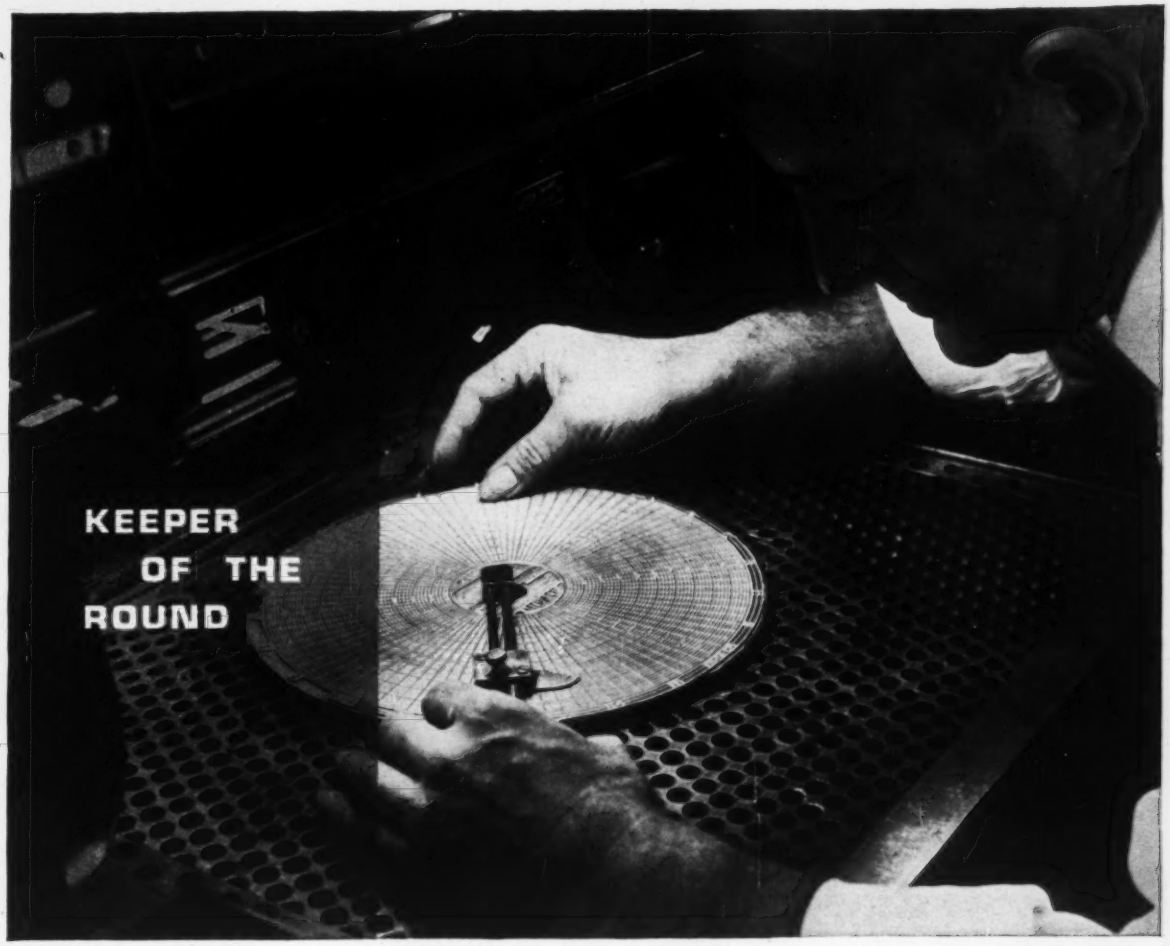
May 11-14
Fluid Controls Institute 1960 Spring Meeting, The Greenbrier, White Sulphur Springs, West Virginia. For information write E. R. Rath, P.O. Box 667, Pompano Beach, Florida.

May 17-18
Symposium on Superconductive Techniques for Computing Systems, Dept. of Interior Auditorium on C St., between 18th and 19th Sts. N.W., Washington, D.C. For information write Josephine Leno, Code 430A, Office of Naval Research, Washington 25, D.C.

May 18-20
1960 Spring Meeting of Society for Experimental Stress Analysis, Hotel Severin, Indianapolis, Indiana. For information write SESA, P.O. Box 168, Cambridge 39, Mass.

May 23-25
National Telemetering Conference, Miramar Hotel, Santa Monica, Calif. For information write Roy E. Colander, 8345 Hayvenhurst, Sepulveda, Calif.

June 16-18
Fifth Annual Symposium and Exhibit of American Scientific Glassblowers Society, Penn-Sheraton Hotel, Pittsburgh, Penna. For information write W. E. Barr, Gulf Research & Development Company, P. O. Box 2038, Pittsburgh 30, Penna.



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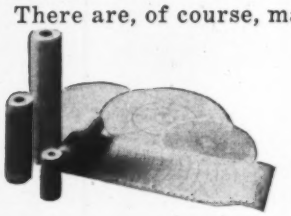

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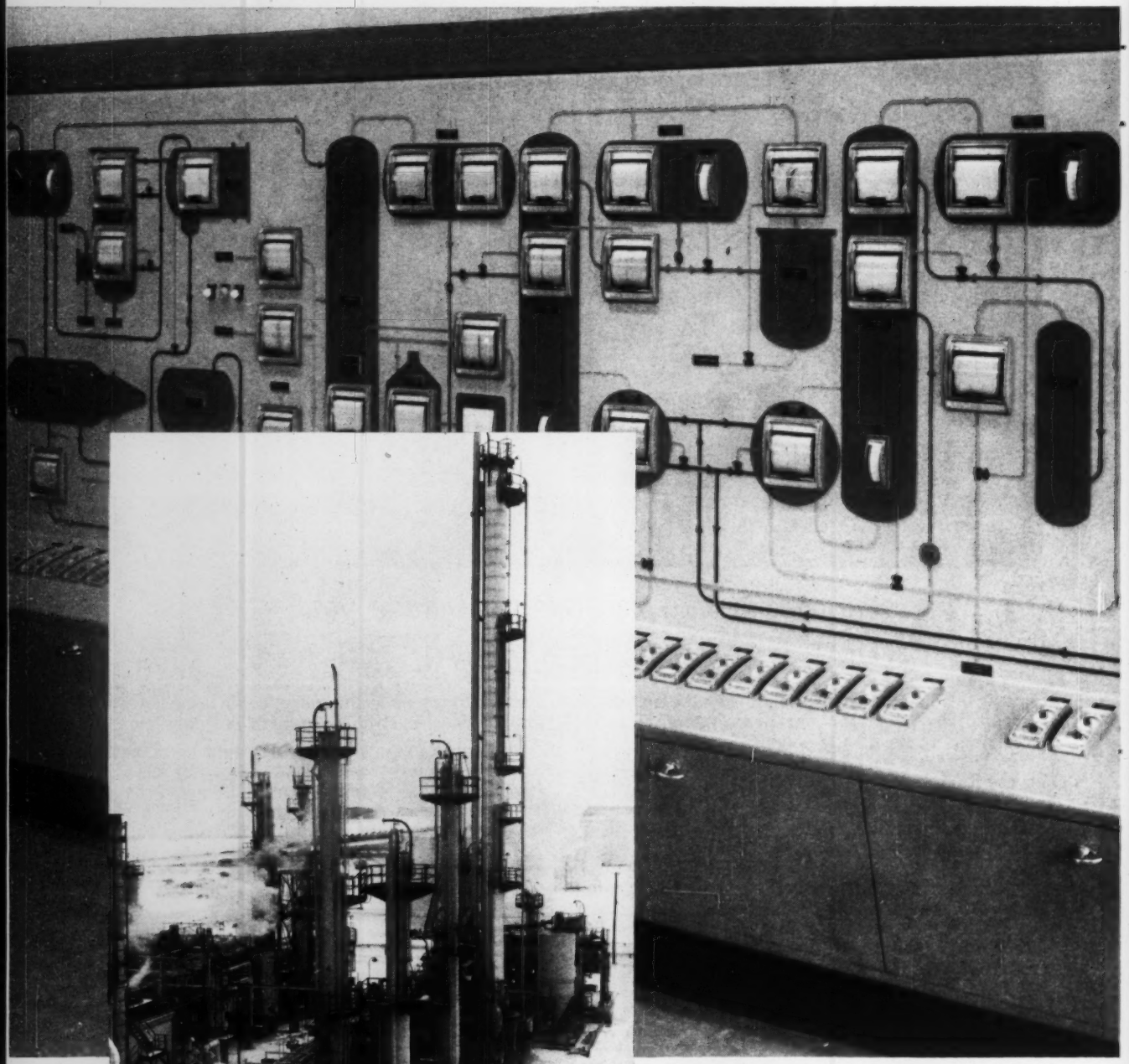
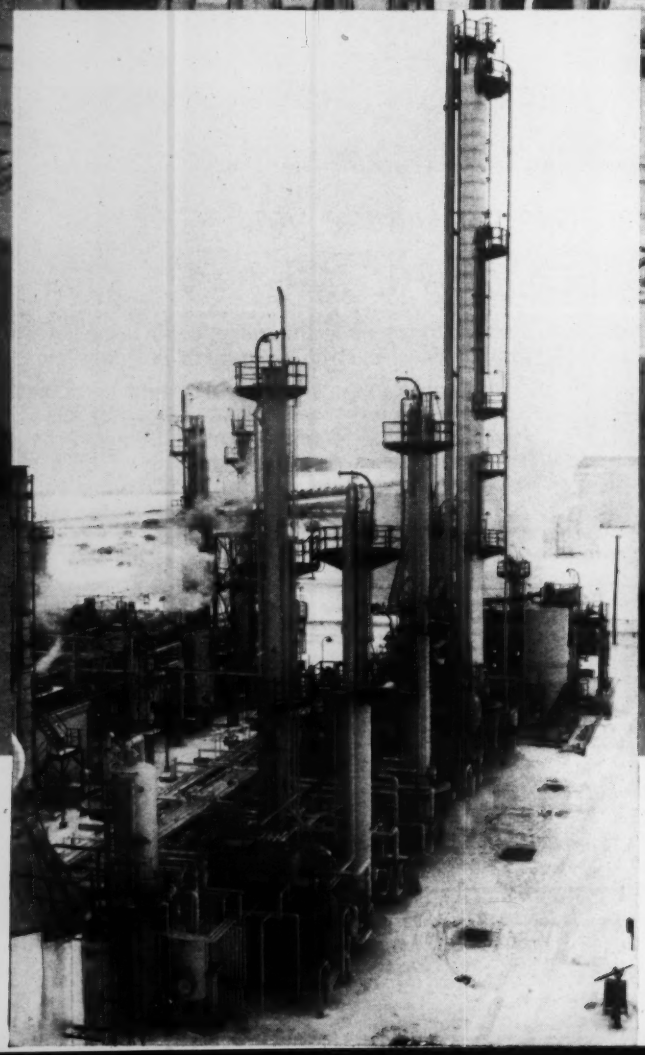
CIRCLE 57 ON READER-SERVICE CARD

at Imperial Oil Limited

They wanted a low
they chose Foxboro



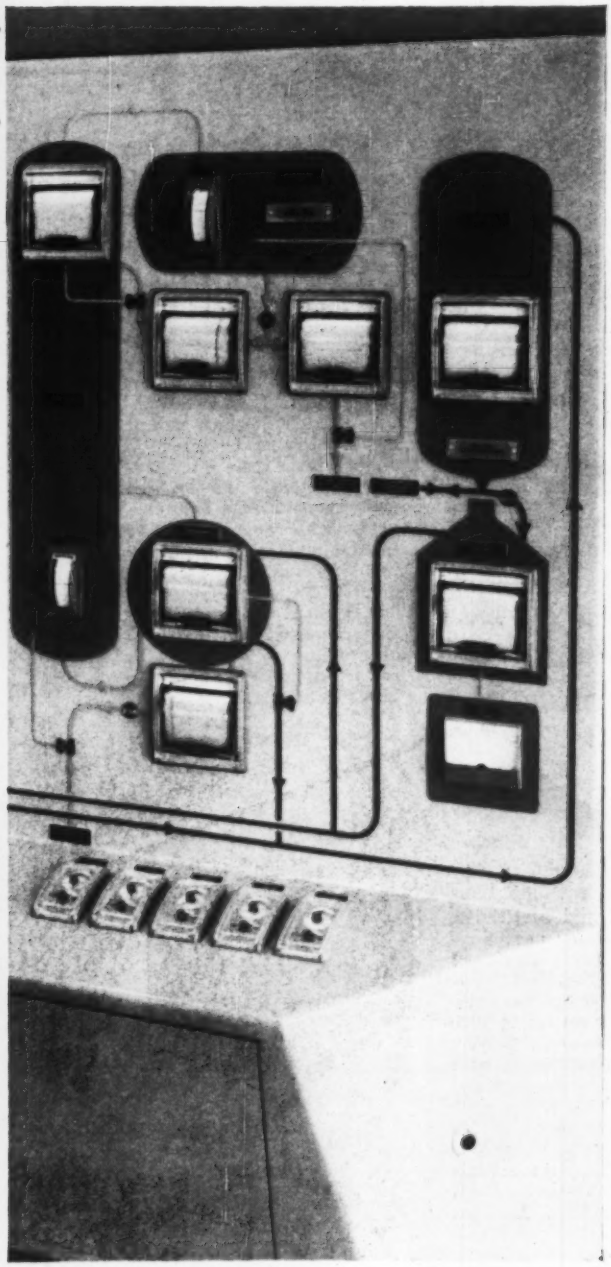


◀ New Hydrofluoric Acid Alkylation Unit at Imperial Oil Limited, Winnipeg, Manitoba. Unit was designed by the Universal Oil Products Company for Imperial Oil.

CIRCLE 58 ON READER-SERVICE CARD

PHOTOGRAPHY BY FREDERIC ALKIER, WINNIPEG

maintenance electronic system... Electronic Consotrol instrumentation



▲ **FOXBORO ELECTRONIC CONSOTROL PANEL** at Imperial Oil includes 32 control loops. 3″ x 6″ Control Stations are so compact they are mounted on panel console, while recorders are mounted directly in the graphic diagram above.

problems of "frozen" air and vacuum tubes eliminated in new HF Alkylation Unit at Winnipeg, Manitoba

There were significant reasons for installing Foxboro Electronic Consotrol* Instrumentation on Imperial Oil's new HF Alkylation Unit in Winnipeg, Manitoba.

First — Foxboro electronics completely eliminated their problem of air supply — particularly vexing in a climate where the temperature drops below freezing 9 months out of the year.

And second — they like Foxboro's "all solid state" feature, because they'll never have an instrument failure due to a burned out vacuum tube.

Imperial Oil also appreciates the compactness of Foxboro electronic control panels. Compact 3″ x 6″ controllers are located on sloping panel console — 4-inch strip chart recorders are integrally-mounted in graphic diagram. With a minimum of searching, the operator knows how the process stands.

If speed of response, sensitivity, and reliability play an important role in your process, it will pay you to investigate Foxboro Electronic Consotrol instrumentation. Ask your Foxboro Field Engineer about it. Or write for Bulletin 21-10. The Foxboro Company, 464 Neponset Avenue, Foxboro, Massachusetts.

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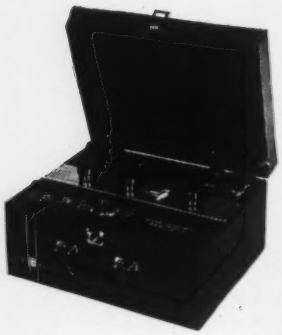
CIRCLE 58 ON READER-SERVICE CARD

Make speedier checks of recorders, controllers and base or noble metal thermocouples in industrial plants with the new three-dial 8686 Portable Millivolt Potentiometer. Features such as a central reading window . . . where measured values appear as a row of digits with a scale interpolation . . . simplify calibration of thermocouples and test measurements. The 8686 Potentiometer has: a wide operating range of −10.0 to +100.1 mv and +1010 to +1020 mv for standard cell calibration; and a high accuracy of ±(0.05% of reading +3μv) without reference junction compensation, ±(0.05% of reading + 6 μv) with ref. jct. comp. Write for Data Sheet E-33(1A).



8686 Millivolt Potentiometer

8690 Millivolt Potentiometer

Fast, accurate in-plant checking of thermocouples, recorders and controllers is expedited by the new 8690 Portable Millivolt Potentiometer. Design features such as "In-line Readout", which permit measured values to be read in digits with a scale interpolation, accelerate temperature measurements. The 8690 provides a wide range of −11.0 to +101.0 mv which eliminates input reversals; an accuracy of ±(0.05% of reading + 20 μv) without reference junction compensation, ±(0.05% of reading + 40 μv) with ref. jct. comp. Write for Data Sheet E-33(1B).

8692 and 8693 Temperature Potentiometers

If you want to make a variety of temperature measurments quickly with one flexible instrument, investigate the new time-saving 8692 Single-Range or 8693 Double-Range Temperature Potentiometers. Available in any of 24 interchangeable temperature and millivolt ranges, these instruments read directly in degrees F or C on a scale 27½" long. Convenience features include: simplified range changes . . . only a screwdriver is needed to change a circuit panel, scale and binding post studs; automatic reference junction compensation . . . reference coil, built into circuit panel, compensates for thermocouple being used; accuracy . . . ±0.2% of range. Write for Data Sheet ND42-33(1A).

4 time-saving instruments from the

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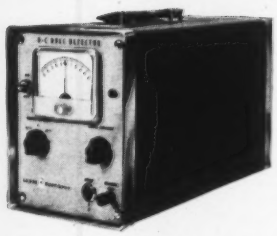
CONVENIENCE-STYLED L&N LINE . . .

Need a fast-operating, high-sensitivity, high-quality null indicator for use in research, testing and production checking? Here's a new 9834 Guarded D-C Null Detector having a short period of less than two seconds for source resistances up to 1000 ohms, increasing to 4 seconds at 100,000 ohms . . . ideal for measurements with guarded or unguarded potentiometers and bridges. Of rugged construction, this portable, line-operated detector provides numerous convenience features which include four degrees of sensitivity, with a basic sensitivity of 0.2 μv/mm (0.3 μv/scale div.), and a noise level of less than ±0.1 μv. Write for Data Sheet ED7(2).



9834 Guarded D-C Null Detector

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FOR DATA SHEET E-33 (1A) CIRCLE 59, ND-42-33 (1A) CIRCLE 60, E-33 (1B) CIRCLE 61, ED-7 (2) CIRCLE 62

Automation's Challenge to Management

GEORGE M. MUSCHAMP
Industrial Products Group
Minneapolis-Honeywell Regulator Company

WHAT IS THERE new in the situation we face now and as we look to the future over what we faced some time ago? In my 30 years in instrumentation and control, I find that most of the situations and problems keep repeating themselves. There is a saying that the more a thing changes, the more it remains the same, and many things, as I see it, are the same. However, the attitude of management to instrumentation is changing.

Management has seen ample demonstration not only in the plant but also in the office and in the laboratory of what automatic aids can do. This changing management climate offers a tremendous opportunity to instrumentation and automatic control people.

Many companies today have recognized the desirability of setting up centralized groups with the proper talents to study promising processes for complete automatic control. I know of several situations recently in which plant managers, on their own initiative, have bought expensive systems which their control groups seemed reluctant to sanction. The advance of the art will be served better if such steps are taken with the advice and guidance of you who are the experts in your field.

In a recent survey into the service and maintenance of a certain class of instrumentation system —competitive as well as our own—we found that the systems that were not functioning properly were those specified by others in the company than those using them, while those specified by the people using them all seemed to be performing satisfactorily. This suggests that, if the control instrument group can exercise control over the harmonious correlation of the study of such systems, if not the actual purchasing of them, they will be doing their employers a great service. It ought to be possible for a systems or instrument group to work out a joint arrangement with the operating groups so that the operating groups would undertake such jobs with the same enthusiasm and tenacity as they would if the ideas were their own.

Situations such as this simply demonstrate the difficulties of establishing sound control systems from a subordinate position or without full authority. Yet I see no immediate possibility of control engineers assuming dominant positions within the corporate structure, although the notion has been advanced by system engineering advocates.

What is clear is that the scope of automatic control problems is constantly widening and thus taking the problems and decisions closer to top management. As systems becomes larger, they tend to cross traditional group or departmental lines and this sometimes calls for actual reorganization. Moreover, the consideration of what might originally have been thought to be a pure automatic control problem may now involve the process itself. The consideration of digital computer-directed control systems is an example of the interrelationships.

In pushing the state of the art as we are doing—and I hope we always shall—we are asking computers to do things which people are not now doing. This is one of the most important facts about computer-directed control systems.

It is a common experience in making studies for working out the installation of computers and data processing systems in banking, insurance and other business operations to find that the review of existing practices itself results in improvements that might be made independently of any automation considerations. This same thing has been experienced in the linear programming efforts in industrial plants. Every job that every computer group has tackled, whether it is an equipment manufacturer or a user group, has resulted in process improvements which are important—irrespective of the ultimate decision to buy or not to buy a computer. These improvements themselves are more important in some cases than the decision on the computer.

In a sense, the computer is only the vehicle to do things which probably should have been done before. These new things bear importantly on the economics of operation. Because they are economic, they involve upper management more and more.

Instrument manufacturers are confronted with the same challenging situation. We have to face a

Abstracts from an address presented to the New York Section, ISA, February 10, 1960

Continued from page 577

spectrum of apparatus and system situations varying from a simple thermocouple though the various variables, equipments, techniques and sizes, to complex data-handling systems, analog computers and now the sophisticated digital computers.

This would be challenge enough if it involved only the supply of equipment. But much more is involved. Basic to this challenge is the provision of suitable system engineering so as to insure the proper integration of this infinitely complex mass of equipment in economically and technically sound systems. This responsibility, as well as that of training and maintenance, is part of what the instrument manufacturer must assume if he is to make the most of the present automatic control opportunities.

The challenge to top management becomes enormous in terms of the risks to be taken—risks of the large costs of these systems if the challenge is met, risks of the loss of competitive position if the challenge is not met. Yet the continuing rise in labor costs, the sharp competition in prices and quality both at home and abroad, and the expansion into new fields with limited technical and production manpower are factors which really leave top management with little choice but to push automation to the utmost.

1960 IRE Show

With more than 69,000 attendance, 1000 exhibits, 25,000 products on display, 2½ miles of corridors and 270 papers, the 1960 IRE International Convention had something for everybody—components, instruments, subsystems, systems; solid state, vacuum, gaseous; audio, infrared, shf; micro and macro products.

The technical sessions also covered every phase of modern technology from military to medical (with, alas, more emphasis on the former than the latter). One of the most significant developments of the past year has been the reduction in the inherent noise level of amplifiers by use of maser and parametric-amplifier techniques. The technical sessions showed the many ways in which this important development is being put to use, particularly in the space program. Much attention also was paid to the Esaki, or tunnel, diode. Featuring small size, low power requirement, freedom from radiation effect and (anticipated) low cost, it was covered in many fine papers.

In the field of hardware, there was exciting news in analog computing, digital equipment, recording and calibration instrumentation.

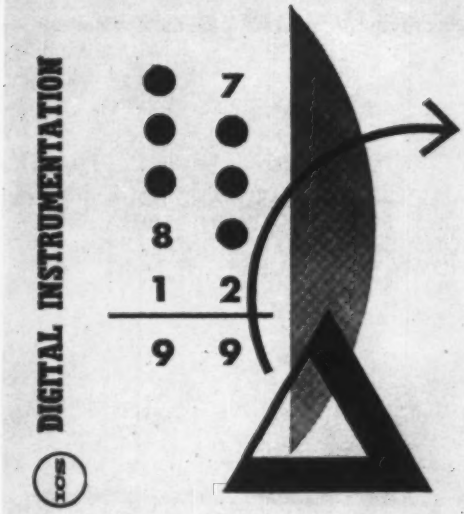
The big news in analog computing is the introduction of two new firms into this field—*General Computers, Inc.* of Los Angeles and *Applied Dynamics, Inc.* of Ann Arbor. Both offer general-purpose analog computers featuring modular construction, small initial size, but easy expansibility. We wish both companies well, as *INSTRUMENT AND CONTROL SYSTEMS* has for years pioneered and advocated the use of analog computers in "systems engineering."

The activity in the digital field can be called feverish at all levels—scanners and commutators, digital converters, memories, digital readout instruments, and computers. Your editors picked out the following equipments (with apologies to the hundreds that are not mentioned) as being particularly significant:

General Mills introduced the 2003 solid-state digital computer, featuring core memory, addition time of 80 microsecond, and 64 instructions which can be altered simply by insertion of cards; *Packard Bell* introduced the general-purpose *pb* computer, also solid state, with 12 microsecond addition time, 46 instructions and a surprising price—only $30,000; also a high-speed electronic multiplexer with 15 microsecond switching time; also a 10 kc solid-state encoder, the M3 Multiverter, with a conversion rate of 10,400/second. *San Diego Scientific* (a new firm), introduced the Magne-plexer, a magnetic multiplexer for the commutation of low-level signals at rates to 50 kc; *Radiation, Inc.*, introduced the Radiplex 89 data acquisition system which can multiplex and sample 96 channels at a rate of 312.5 samples per second, and can handle 10-microvolt signals. *Electro-Instruments* also introduced the Model 701 low-level (10-μv signal) scanner with 100 inputs and scan rate of 500/second; also the "first true RMS Digital Voltmeter." *Systron* introduced a 10-Mc counter-timer and another new firm, *Transistor Specialties* introduced a 1-Mc counter-timer.

In the field of recording, the following developments are noteworthy: *Texas Instruments* introduced galvanometer recorders in flush-type rugged industrial models; *Systron* introduced a new line of potentiometer recorders; *Century Electronics* introduced a glamorous Model 450 portable null-balance potentiometer recorder that will operate up to 8 days on 8 dry cells. *Brush* introduced models featuring combined analog and on-off channels in one instrument, a new trend for obtaining maximum number of channels in one instrument.

DIGITAL INSTRUMENTATION



Addition and Subtraction by Symbolic Logic

Previous articles have explained the symbolic-logic equation, the manipulation of the equation into various forms, the use of logic charts and truth tables, and the implementation of the equation by use of gates. These techniques are applied here to the basic digital functions of addition and subtraction.

ROBERT BROOKS
Computer Control Co., Inc.

IN BINARY arithmetic, the *addition rules* are:

A =	0	0	1	1
+B =	+0	+1	+0	+1
Sum S =	0	1	1	0 carry 1 to next higher column.

To secure the proper sum digit (S) in a column, three quantities must be considered—A, B, and the carry digit C from the adjacent lower-ordered column. The complete addition rules can be stated in words as follows: Create a sum digit whenever the total number of 1's present in the three variables is an odd number. Create a carry digit equal to 1 for the next higher-ordered column whenever the total number of 1's present is two or more.

A truth table (Table 1) can be used to show the addition rules. The two equations under the truth table express the rules of binary addition in symbolic-logic form. The truth table yields the basic equations for the sum (S) and carry (C) terms; C_p is a carry from a previous column.

In previous discussions it has been shown that these equations can be implemented either (1) directly[1] by manipulating the equations into their simplest form and using gates or (2) by use of a logic chart[2], each square of which can be implemented by an appropriate gate.

The use of the latter technique is shown in Fig. 1, which shows the logic chart for addition and its implementation.

The shaded squares are those that result in a sum digit or a carry digit equal to 1. Note that two packages (a sum package and carry package) are required to add a column consisting of two binary digits because two equations must be solved.

When the binary numbers are presented to the adder in serial form, only two packages are required to accomplish the addition. Each column is added in sequence, and the carry pulse is delayed 1 pulse period so that it plays a role in the addition of the next column.

When the binary numbers are presented to the adder in parallel form, two packages *per column* are required.[3] In this type of adder, the carry pulse from each column is presented to the next higher-order column so that the proper sum is created.

Fig. 1 shows the implementation of the two equations in Table 1. In the sum circuit, each square in

Inputs			Output		S exists when	C exists when
A	B	Cp	S	C		
0	0	0	0	0		
0	0	1	1	0	$\bar{A}\cdot\bar{B}\cdot C_p$	
0	1	0	1	0	$\bar{A}\cdot B\cdot\bar{C}_p$	
1	0	0	1	0	$A\cdot\bar{B}\cdot\bar{C}_p$	
0	1	1	0	1		$\bar{A}\cdot B\cdot C_p$
1	0	1	0	1		$A\cdot\bar{B}\cdot C_p$
1	1	0	0	1		$A\cdot B\cdot\bar{C}_p$
1	1	1	1	1	$A\cdot B\cdot C_p$	$A\cdot B\cdot C_p$

$$S = \bar{A}\cdot\bar{B}\cdot C_p \; v \; \bar{A}\cdot B\cdot\bar{C}_p \; v \; A\cdot\bar{B}\cdot\bar{C}_p \; v \; A\cdot B\cdot C_p$$

$$C = \bar{A}\cdot B\cdot C_p \; v \; A\cdot B\cdot C_p \; v \; A\cdot\bar{B}\cdot C_p \; v \; A\cdot B\cdot\bar{C}_p$$

TABLE 1—TRUTH TABLE AND EQUATIONS FOR ADDITION. EQUATIONS EXPRESS THE CONDITIONS SHOWN TO BE TRUE BY THE TABLE

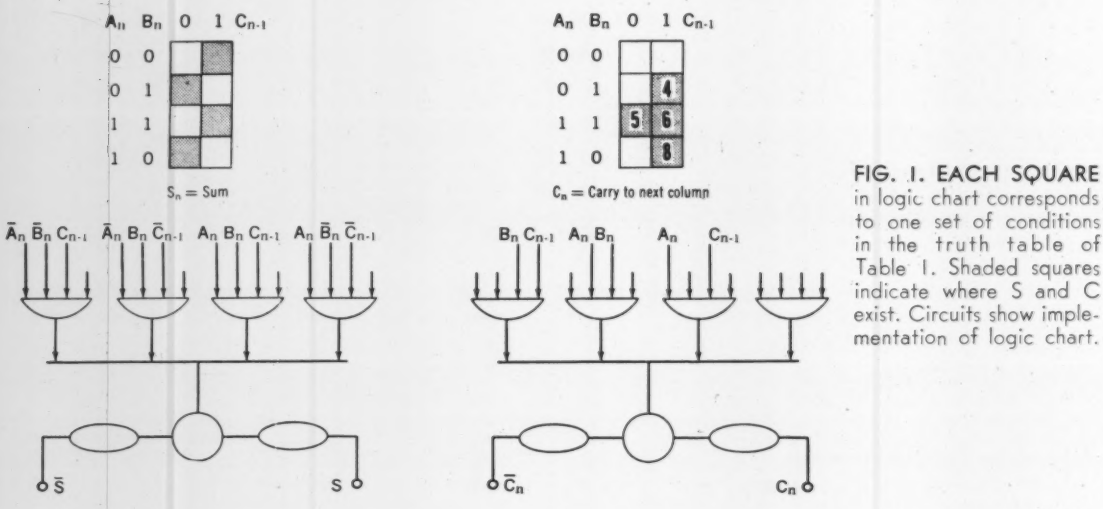


FIG. 1. EACH SQUARE in logic chart corresponds to one set of conditions in the truth table of Table 1. Shaded squares indicate where S and C exist. Circuits show implementation of logic chart.

the logic chart is directly implemented by one gate.[2]

However, in the carry circuit a simplification has been made by considering squares 4 and 6 as one B•C term. (It has previously been explained[2] how the two adjacent squares can be considered as one term.) Similarly, squares 5 and 6 can be represented by A•B, and squares 6 and 8 by the term A•C.

Thus the expression for C becomes

$$C = B\cdot C \; v \; A\cdot B \; v \; A\cdot C$$

This same expression can be realized by simplification of the equation for C shown in Table 1, using the postulate that A and NOT A (or B and NOT B, etc.) equals 1, as explained previously[1]. Using this postulate, it is seen that the first two terms in the expression for C in Table 1 reduce simply to B•C; the second and third terms reduce to A•C; the second and fourth terms reduce to A•B. Note that the second term was used three times in this process. This is permissible because in symbolic logic, if a term exists, it can be used as often as desired—that it, A is the same as A v A.

Fig. 1 thus shows the connections for a binary full adder, using the gates available in a commercial package[2]. (A solution to this same problem of addition previously was given using only 2-leg gates.[1])

Binary Subtracter

In binary arithmetic, the subtraction rules are:

X =	0	1	1	0	
−Y =	−0	−0	−1	−1	
Difference (D) =	0	1	0	1	and borrow 1 from next higher column

Sample problem 1:

X =	10000 =	16
−Y =	−1 =	−1
D =	1111 =	15

TABLE 2—TRUTH TABLE AND EQUATIONS FOR SUBTRACTION. EQUATIONS EXPRESS THE CONDITIONS SHOWN TO BE TRUE BY THE TABLE.

Inputs			Output		D exists when	B exists when
X	Y	B_p	D	B_n		
0	0	0	0	0		
0	0	1	1	1	$\bar{X}\cdot\bar{Y}\cdot B_p$	$\bar{X}\cdot\bar{Y}\cdot B_p$
0	1	0	1	1	$\bar{X}\cdot Y\cdot\bar{B}_p$	$\bar{X}\cdot Y\cdot\bar{B}_p$
1	0	0	1	0	$X\cdot\bar{Y}\cdot\bar{B}_p$	
0	1	1	0	1		$\bar{X}\cdot Y\cdot B_p$
1	0	1	0	0		
1	1	0	0	0		
1	1	1	1	1	$X\cdot Y\cdot B_p$	$X\cdot Y\cdot B_p$

$$D = \bar{X}\cdot\bar{Y}\cdot B_p \vee \bar{X}\cdot Y\cdot\bar{B}_p \vee X\cdot\bar{Y}\cdot\bar{B}_p \vee X\cdot Y\cdot B_p$$

$$B = \bar{X}\cdot\bar{Y}\cdot B_p \vee \bar{X}\cdot Y\cdot\bar{B}_p \vee \bar{X}\cdot Y\cdot B_p \vee X\cdot Y\cdot B_p$$

$$= \bar{X}\cdot B_p \vee \bar{X}\cdot Y \vee Y\cdot B_p$$

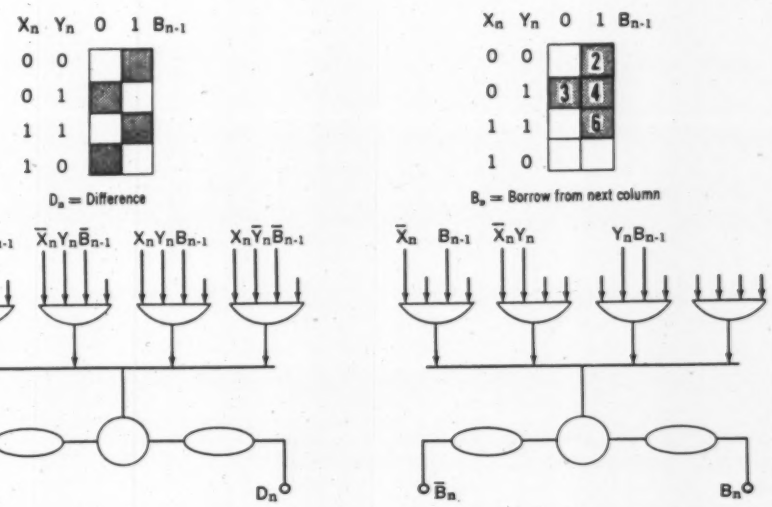


FIG. 2. LOGIC CHART for conditions of truth table in Table 2, and implementation with gates.

Sample problem 2:

$$\begin{array}{rrr} X = & 1100 = & 12 \\ -Y = & -0111 = & -7 \\ \hline D = & 0101 = & 5 \end{array}$$

To secure the proper difference digit (D) in a column, three quantities (X, Y, and borrow digit B from the adjacent lower-ordered column) must be considered. The complete subtraction rules can be stated as follows: Create a difference digit (D) equal to 1 for this column whenever the total number of 1's present in the three variables (X, Y, B) is an odd number; create a borrow digit whenever all three variables each equal 1 or whenever X is equal to 0 and Y or B equals 1.

The truth table (Table 2) shows all the possible combinations of X, Y, B, and D. It also shows the equations for D and B.

Fig. 2 shows the logic chart representing Table 2, plus its implementation.

As in the addition problem, each square in the logic chart for D is implemented directly by an appropriate gate. However, in the implementation of B, squares 2 and 4 are represented by $B\cdot\bar{x}$; squares 3 and 4 by $Y\cdot\bar{x}$; squares 4 and 6 by $Y\cdot B$. This is shown in Fig. 2. Serial subtraction requires two packages, while parallel subtraction requires two packages per column.

References

1. Gary A. Wires, "Boolean Algebra," *I&CS*, Feb., 1960.

2. Robert Brooks, "Digital Systems by Symbolic Logic," *I&CS*, March, 1960.

3. Robert Brooks, "Logical Design with Symbolic Logic," *I&CS*, March, 1957, p. 462.

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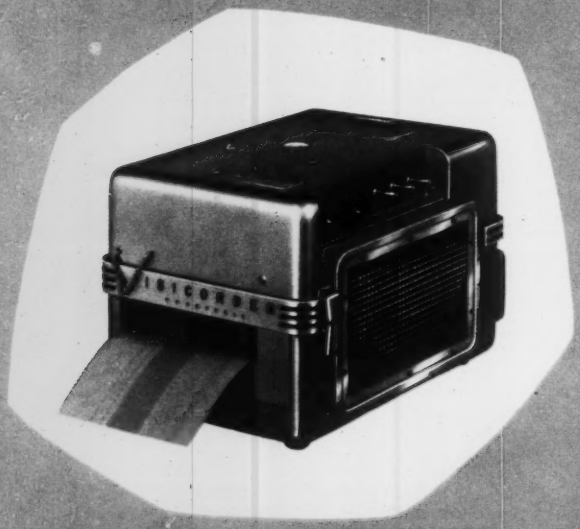
The 906 B-1 provides for 14 channels of recording including two static reference traces —each channel operating at frequencies from DC to 5000 cps. It has provisions for recording intensity control; trace identification; grid line system (either inches or millimeters) and selectable record speeds (a choice of 5 interchangeable systems, each covering 4 speeds).

The Model 906 B-2 is identical to the 906 B-1, except that it uses solid-frame galvanometers with a capacity of 8 channels, including 2 timing or event-marking channels.

Accessories available for both models of the 906 B include a record take-up unit; record takeup and latensifier; relay rack adapters; and the Visicorder Timing Unit.



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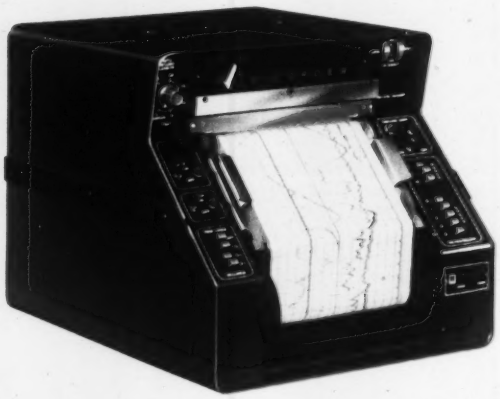
MODEL 1108 VISICORDER

. . . newest of the Honeywell direct-recording oscillographs

The Model 1108 delivers direct-writing Visicorder oscillography at the lowest cost per channel. Intermediate in size between the 14-channel 906 and the 36-channel 1012, the 1108 simultaneously records up to 24 channels of data on a record 8 inches wide. This instrument, like other Visicorders, records at frequencies from DC to 5000 cps with unparalleled galvanometer sensitivities.

Pushbutton controls give a choice of 15 record speeds from .05 to 80 inches per second, and time line intervals of 1, .1 and .01 seconds. Such built-in features as automatic record length control, grid-line intensity control, galvanometer spot intensity control, record numbering, reversible record drive, trace identification, provision for remote operation, and many others contribute to maximum convenience in recording high-speed analog data.

As in all Honeywell Visicorders, paper loading, access to the interior, and galvanometer adjustment is easy and convenient.



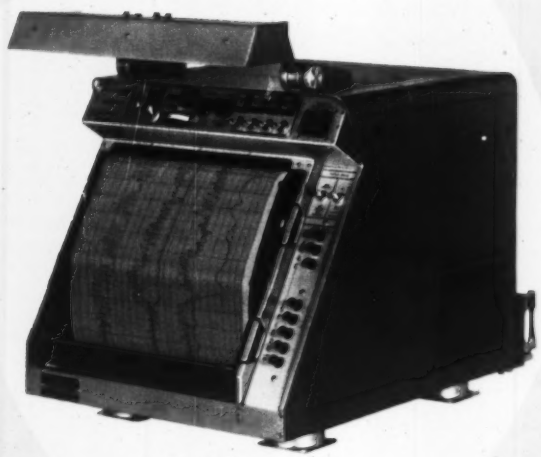
Honeywell

MODEL 1012 VISICORDER

. . . the most complete, convenient multi-channel oscillograph on the market today

The Model 1012 has been accepted as "the most versatile instrument ever devised for converting dynamic data into immediately visible read-out." It will record up to 36 channels of data simultaneously on 12" wide paper. It gives complete push-button control of 15 different paper speeds, from 0.1 to 160 in./sec., with automatic recording intensity control. Designed into the 1012 are many other convenience features: daylight paper loading; reversible record drive choice; switch selection of 5 different timing intervals (.001 to 10.0 seconds); simultaneous recording of amplitude reference (grid) lines; trace identification; automatic record length control; record numbering; jump-speed control and provisions for remote and/or multiplexed operation.

Like other Visicorders, the 1012 makes use of the sub-miniature galvanometer. All instruments are readily adaptable to rack and shock-mounting.



Honeywell

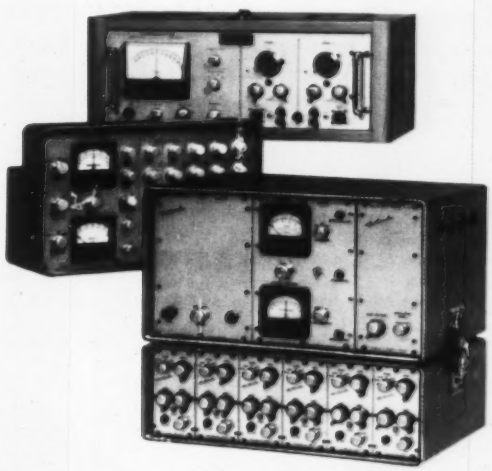
SIGNAL-CONDITIONING SYSTEMS

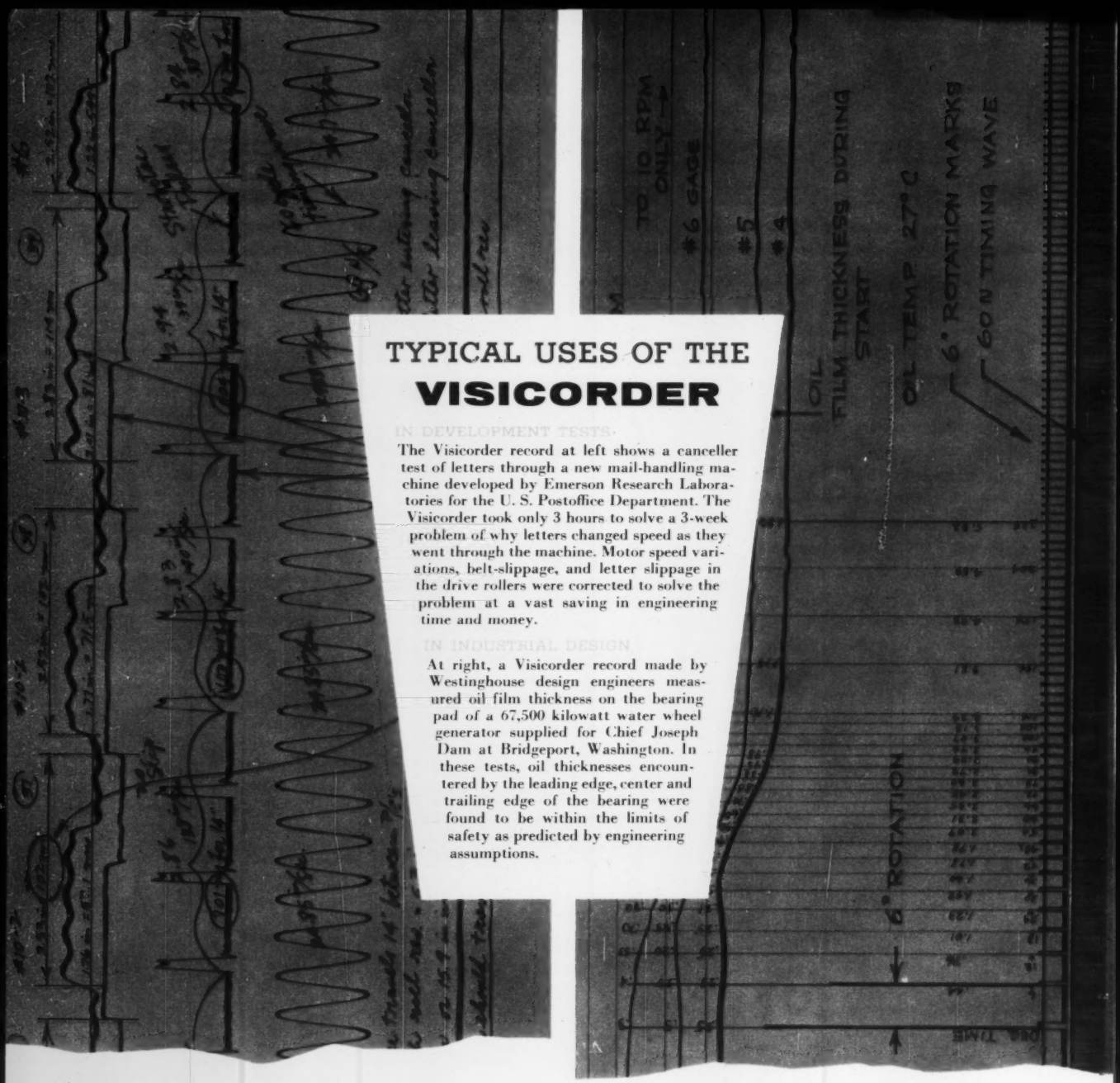
A. The Model 119 Amplifier System . . . a simple and accurate 6-channel carrier amplifier, for use in oscillographic recording, which may be converted to a linear/integrating system simply by installing linear/integrating channels in the same case. The carrier amplifier is designed to amplify signals from resistive, variable-reluctance, differential-transformer, and capacitive transducers. The linear/integrate amplifier is used in conjunction with self-generating transducers such as vibration pickups, etc. The carrier system provides recordings in the 0-1000 cps range at galvanometer amplitudes of 8" peak-to-peak. The linear-integrate system accommodates frequencies from 5-5000 cps.

B. The Model 130-2C Carrier Amplifier . . . a two-channel unit for use with resistance, reluctance, differential transformer, and capacitive transducers. Produces 8-inch (peak-to-peak) galvanometer deflections up to 1000 cps from as little as 0.5 mv gage output.

C. The Model 82-6 Bridge Balance and Strain Indicator . . . a simple, accurate 6-channel unit for calibrating, balancing, controlling, and measuring static and dynamic phenomena from resistive transducers.

All three of these units are suitable for convenient rack mounting.





TYPICAL USES OF THE VISICORDER

IN DEVELOPMENT TESTS:

The Visicorder record at left shows a canceller test of letters through a new mail-handling machine developed by Emerson Research Laboratories for the U. S. Postoffice Department. The Visicorder took only 3 hours to solve a 3-week problem of why letters changed speed as they went through the machine. Motor speed variations, belt-slippage, and letter slippage in the drive rollers were corrected to solve the problem at a vast saving in engineering time and money.

IN INDUSTRIAL DESIGN:

At right, a Visicorder record made by Westinghouse design engineers measured oil film thickness on the bearing pad of a 67,500 kilowatt water wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, oil thicknesses encountered by the leading edge, center and trailing edge of the bearing were found to be within the limits of safety as predicted by engineering assumptions.

OTHER USES of the Visicorder . . . as a direct readout unit **IN RECORDING AND MONITORING SYSTEMS . . . IN MISSILE AND ENGINE ANALYSIS** for test stand recording . . . for analog recording **OF TELEMETERED SIGNALS . . . IN CONTROL** to monitor reference and error signals . . . **IN NUCLEAR TEST** to record temperatures, pressures, impacts, etc. . . . **IN LABORATORIES** for all-purpose analysis . . . **IN PRODUCTION** for final dynamic inspection . . . **IN COMPUTING** for immediately-readable analog records . . . **IN PILOT COMPONENT TESTS** for rapid evaluation of prototypes . . . **IN ALL TESTS** which are non-repetitive in sequence, making oscilloscopes impractical.

Write for your *free* copy of the new 36-page Visicorder Applications Manual, a comprehensive, detailed guidebook to many varied uses of the Visicorder.

Honeywell

Industrial Products Group

For further information including prices and delivery, write
Minneapolis-Honeywell Regulator Company, Industrial Products Group, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado.

THE ELECTRICAL STANDARDS LAB

Here are the instruments used and the resultant measurement accuracy capabilities of one of the country's finest standards and calibration facilities

CHARLES E. WHITE
AVCO Research & Advancement Development

MOST STANDARDIZING activities require (1) electrical measurements, (2) time and/or frequency measurements, and (3) mechanical measurements. As the complexity of the functions carried out by the parent activity increases, so also does the standards laboratory associated with the activity find itself forced into newer and wider fields. The least hint of reasearch or development will ultimately call for establishment of standardized controls in the environmental fields of temperature, pressure, vacuum, vibration and acceleration. The laboratory will find itself enmeshed in the calibration of more intricate electrical functions—capacitance and inductance; microwave characteristics such as noise figures, power, voltage, attenuation and Q; mechanical measurements may be expanded to encompass flatness, surface finish, microhardness and small angular deflections.

In the establishment and maintenance of standards laboratories, complacency is an attitude never to be tolerated. The entire personnel must be trained to seek continually for refinements in measurements, for more accuracy, for improved techniques. They should be alert continually to the part the laboratories play in the reliability and quality of the product manufactured by the parent activity, whether it be research or a fabricated unit. To do this calls for staffing and equipping the laboratories with personnel and facilities suitable for the purposes of calibration. They should have a flexibility in approach and appliance which will permit extension of the laboratories' activities as the forward technical progress of the parent activity takes place.

This philosophy has been established in the Research and Advanced Development Division of AVCO Corporation. It is evidenced by the wide field of activity in which the standards/calibration function is engaged; it is evident in the assemblage of facilities controlled by the laboratories; it is continually pointed up by the active thinking and planning of supervisory personnel for increased application to the company's projects.

Implementing the Standards Activities

Coarse calibrations normally are accomplished on a comparison basis—e.g., a multimeter is compared with a standard meter such as the Weston 326 series or the Sensitive Research Models B or L; a working micrometer is referred to a super micrometer; an audio signal generator is checked by an electronic counter of greater accuracy such as the Hewlett-Packard 524D or the Beckman 7370. *Refined calibrations* may be accomplished in a similar manner when handling particular instruments.

In certain fields there are definite gradations of accuracy of several magnitudes which can be incor-

← CIRCLE 63 ON READER-SERVICE CARD

TABLE 1—ELECTRICAL/ELECTRONIC MEASUREMENT ACCURACY CAPABILITIES

VARIABLE	RANGE	ACCURACY	STANDARD
Voltage DC	Standard Cells	±5 microvolts	Saturated Std. Cells & Comparator
	1 - 11,000 μv	±(0.01% + 0.02 μv)	Thermofree Potentiometer
	11,000 - 111,000 μv	±(0.01% + 0.1 μv)	Thermofree Potentiometer
	0.1 - 1.9 v	±(0.01% + 5 μv)	Wenner Potentiometer
	1.9 - 100 v	±0.01%	Precision Voltage Supply
	100 - 750 v	±0.05%	Potentiometer and Volt Box
	750 - 1500 v	±0.1%	Potentiometer and Volt Box
	1.5k - 30k v	±1.0%	Electrostatic Voltmeter
Voltage AC	10 - 100 mv (50 - 10k cps)	±0.15%	Transfer Voltammeter & Ratio Xfmr
	100 mv - 8 v (50 - 10k cps)	±0.06%	Transfer Voltammeter & Ratio Xfmr
	8 - 300 v (20 - 20k cps)	±0.05%	Transfer Voltammeter
	300 - 1200 v (20 - 20k cps)	±0.2%	Transfer Voltammeter & Volt Box Extension
	1.2k - 6.9 kv (60 cps)	±0.45%	Dynamometer & Voltage Xfmr
	6.9k - 30 kv (60 cps)	±1.0%	Electrostatic Voltmeter
Current DC	0.001 - 0.1 μa	±0.03%	Standard Resistor & Potentiometer
	0.1 μa - 100 ma	±0.02%	Standard Resistor & Potentiometer
	0.1 - 30 a	±0.03%	Standard Rosistor & Potentiometer
	30 - 300 a	±0.05%	Potentiometer & Calibrated Shunt
Current AC	50 ma - 5.0 a (20 - 20k cps)	±0.05%	Transfer Voltammeter
	5.0 - 150 a (20 - 500 cps)	±0.15%	Transfer Voltammeter & Current Xfmr
Power DC	1 mw - 3 kw	±0.04%	Potentiometer & Standard Resistor
	3 - 225 kw	±0.1%	Potentiometer, Shunt & Volt Box
Power AC	0.4 - 1500 w (20 - 20k cps)	±0.1% for unity P.F.	Transfer Voltammeter
	1500 w - 45 kw (50 - 500 cps)	±0.2% for unity P.F.	Transfer Voltammeter & Current Xfmr
	45 - 180 kw (60 cps)	±0.35%	Transfer Voltammeter, Current Xfmr, Volt Box Extension
Resistance Standards	0.001, 0.01, 0.1 ohm	±0.001%	Standard Resistor & Precision Wenner Bridge
	1.0 ohm	±0.0005%	Thomas 1-ohm Std. & precision Wenner Bridge
	10, 100 lk, 10k ohms	±0.001%	Standard Resistor & Precision Wenner Bridge
	100k ohms	±0.002%	Standard Resistor & Precision Wenner Bridge
Intermediate Values	10 - 50 μohms	±0.02 μohms	Kelvin Bridge
	50 μohms - 1 ohm	±0.04%	Kelvin Bridge
	1 - 100,000 ohms	±0.015%	Wheatstone Bridge
	0.1 - 10 megohms	±0.05%	Std. Resistor & Wenner Potentiometer
Inductance Standards	Decimal Multiples of 1, 2, 3, or 5 from 100 - 1000 μh (1k cps) and 2 - 100 mh (1k cps)	±0.5 μh ±0.03%	Std. Inductor & Comparison Bridge Std. Inductor & Comparison Bridge
	0.2, 0.4, 1 h, (50 - 1000 cps)	±0.03%	Std. Inductor & Comparison Bridge
Intermediate Values	0.1 μh - 1000 mh (60 - 10k cps)	±(0.2% + 0.1 μh)	Std. Inductor & Comparison Bridge
	1 - 10 h (1000 cps)	±0.3%	Std. Inductor & Maxwell Bridge
	100 - 1000 h (1000 cps)	±0.6%	Std. Inductor & Maxwell Bridge
Capacitance Standards	Decimal Multiples of 1, 2, 3 or 4 from 10 μμf to 0.1 μf (1000 cps)	±(0.1% + 0.1 μμf)	Std. Capacitor & Mod. Schering Bridge
Intermediate Values	0 - 10 μμf (30 - 300k cps)	±0.01 μμf	Std. Capacitor & Mod. Schering Bridge
	10 - 40 μμf (30 - 300k cps)	±0.04 μμf	Std. Capacitor & Mod. Schering Bridge
	40 - 100 μμf (30 - 300k cps)	±0.1%	Std. Capacitor & Mod. Schering Bridge
	100 - 200 μμf (30 - 300k cps)	±0.2 μμf	Std. Capacitor & Mod. Schering Bridge
	200 -1000 μμf (30 - 300k cps)	±0.1%	Std. Capacitor & Mod. Schering Bridge
	0.001 - 0.1 μf (1k cps)	±0.15%	Std. Capacitor & Mod. Schering Bridge
	0.1 - 100 μf (50 - 20k cps)	±0.3%	Capacitance Comparison Bridge
	100 - 1000 μf (50 - 20k cps)	±0.6%	Capacitance Comparison Bridge

TABLE 2—RF/MICROWAVE MEASUREMENT ACCURACY CAPABILITIES

VARIABLE	RANGE	ACCURACY	STANDARD
Frequency	10, 50, 60, 100 cps	$\pm 1 \times 10^{-8}$ cps	Quartz Crystal Frequency Std. & WWV Time Checks
	1k, 100k 1000k cps and harmonics	$\pm 1 \times 10^{-8}$ cps	Quartz Crystal Frequency Std. & WWV Time Checks
	Frequencies other than harmonics	$\pm 1 \times 10^{-6}$ cps	Frequency Standard, Transfer Oscillator and Electronic Counter
Radio Frequency Standing Wave	100 - 4000 mcps (coaxial line)	±1.0%	Slotted Line and Standard Mismatches
	3.95 - 40k mcps (waveguide)	±1.0%	Slotted Line and Standard Mismatches
Attenuation	1 - 90 db (50 - 10500 mcps)	±0.02 db/10 db	Precision Attenuator & IF Substitution
	1 - 50 db (8.2k - 12.4k mcps)	±0.1 db	Calib. Attenuator & Direct Substitution
	1 - 45 db (12.4k - 18.0k mcps)	±0.2 db	Calib. Attenuator & Direct Substitution
	1 - 35 db (18.0k - 26.5k mcps)	±0.2 db	Calib. Attenuator & Direct Substitution
	1 - 40 db (26.5k - 40.0k mcps)	±0.2 db	Calib. Attenuator & Direct Substitution
Power	.02 - 50 mw (9k - 11.2k mcps)	±1.3% absolute	Power Bridge & Bolometer
	1 - 500 mw (18k - 75k mcps)	±3%	Calorimeter
	10 - 200 w (8.7k - 9.8k mcps)	±2%	Torque Vane Wattmeter

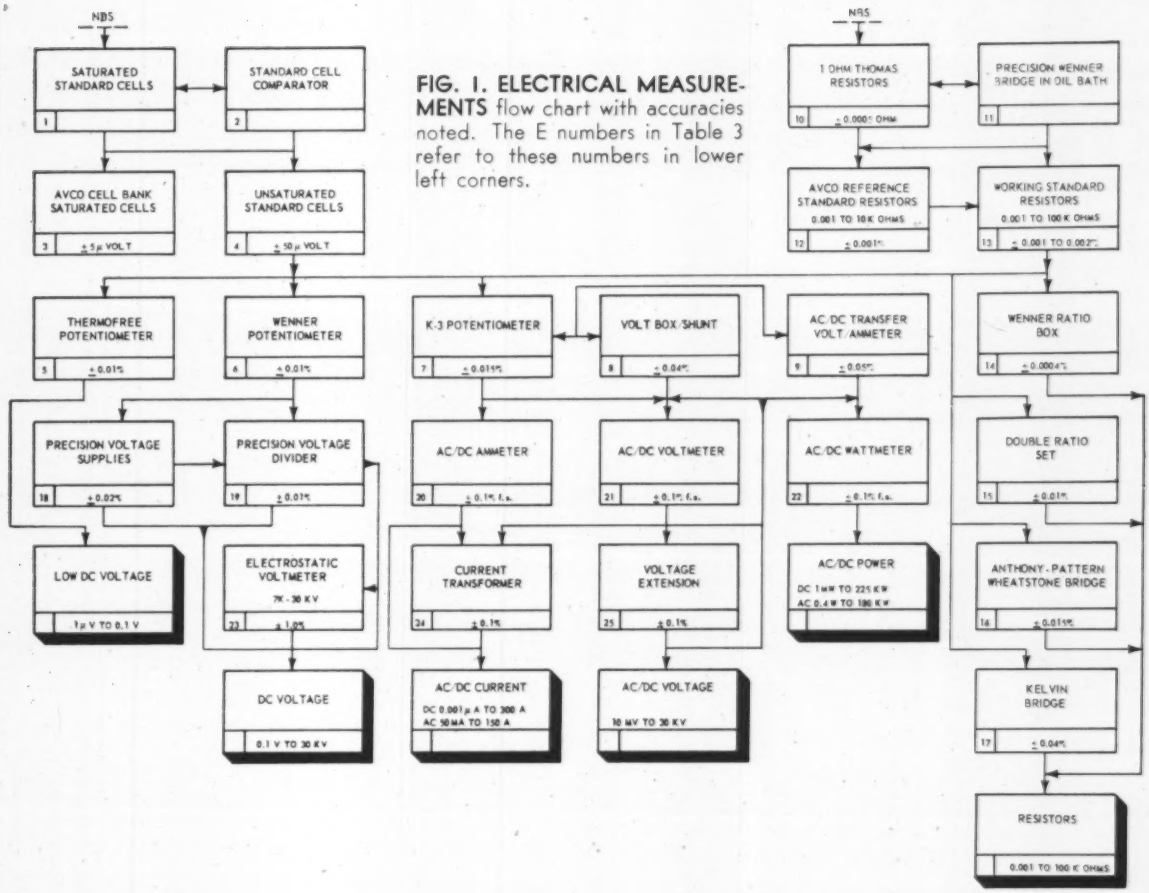


FIG. 1. ELECTRICAL MEASUREMENTS flow chart with accuracies noted. The E numbers in Table 3 refer to these numbers in lower left corners.

porated into instrumentation design and fabrication. In other fields however, such gradation of accuracy can not be attained. The calibration agency then is confronted with the necessity of assembling various instruments and working standards which supply, in toto, the magnitude of accuracy sufficiently great to provide the required level of confidence in the final calibration.

Finally, in calibrating or certifying instruments of the highest level of accuracy the laboratory must resort to a system combining fundamental measurements *reference standards*. This usually requires an assembly of simple units which in combination offer an output of the characteristic and magnitude required. The assembly also offers an accuracy and a confidence level which has been established by a reference or primary standards activity such as the National Bureau of Standards. Such a system might consist of (1) a standard voltage cell, potentiometer, ratio set, galvanometer, (2) a comparator and set of master gage blocks, (3) a signal generator, wave guide and standing-wave detector, indicating null detector, and standard attenuators. These systems are as numerous and as complex as are the measurements which must be certified. They are not limited to the field of measurement represented by the unit being calibrated. As examples, surface finish (a mechanical function) is determined by a combination of mechanical-deflection and electrical/electronic units; microwave power (an electrical function) is determined by a combination of mechanical-heat and electrical/electronic units; absolute pressure (a mechanical function) is measured by a combination of mechanical optical, mechanical-pressure, and electrical/electronic units; humidity (a mechanical-pressure function) may be certified by predetermined reactions of chemical solutions within a closed container.

The field of the *electrical measurements* accuracy capabilities of AVCO R.A.D.'s Reference Standards Laboratories is shown in Tables 1 and 2. Here are listed the activities and ranges in which the laboratories have demonstrated measurement ability. Here also, are listed the standards or techniques associated with the activities.

Figs. 1 to 3 illustrate the manner in which facilities and functions form a common group. These block diagrams not only depict the interrelationships of instrumentation but also trace the legality of measurements from a particular standard submitted to the

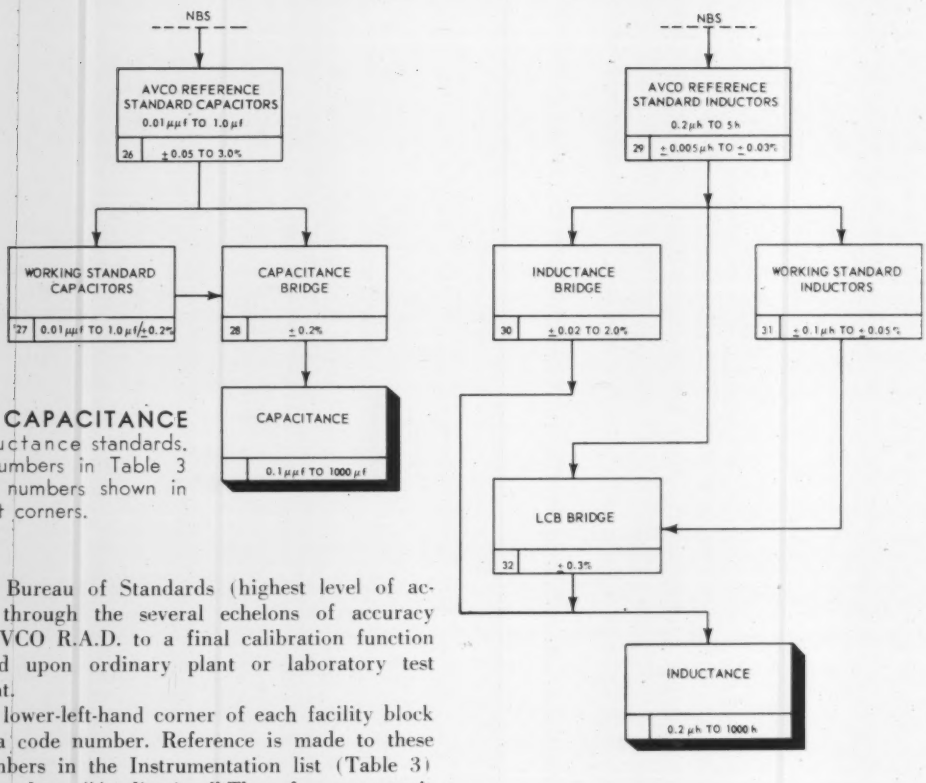


FIG. 2. CAPACITANCE and inductance standards. The E numbers in Table 3 refer to numbers shown in lower left corners.

National Bureau of Standards (highest level of accuracy) through the several echelons of accuracy within AVCO R.A.D. to a final calibration function performed upon ordinary plant or laboratory test equipment.

In the lower-left-hand corner of each facility block appears a code number. Reference is made to these code numbers in the Instrumentation list (Table 3) under the column "Application." The references permit the reader to ascertain the purpose or use of certain instrumentation. Carried one step further, by tracing backward and up from a function, depicted in heavily shaded blocks, a reader is able to determine typical instrumentation required to establish a measurement capability in the particular function area.

In the Instrumentation List, the column designated as "Application" defines the use of each instrument and serves to illustrate the multiplicity of application of many instruments. The prefix letter in each code refers to the letter appearing in the title of each accuracy flow chart block diagram—e.g., "R" for RF/Microwave Laboratory Measurements instrumentation. The number following the prefix letter alludes to the code number in the lower left hand corner of each facility block or function block. The appearance of several code assignments in the applications column signifies diversified use of the instrument or equipment under consideration. Whenever the code letter is followed by zero, as for example "E0", the unit under consideration is regarded as having a common utilization rather than being specifically applied to a particular function. The list does not contain the simplest of associated items which comprise every laboratory's complement of equipment From a practical aspect, each laboratory needs items in the multimeter, soldering-iron classification which are assumed to be available. The list confines itself to units which together or singly serve as fundamental, irreplaceable items required for complete calibrating systems or assemblies. The E numbers refer to Figs. 1 and 2; the R numbers to Fig. 3.

EPPLEY oil bath and Wenner precision bridge. This is unit E11 at upper right in Fig. 1.

In order to save space in the tabulated forms, coding was assigned to all manufacturers of the instrumentation listed in Table 3. Such a practice is a necessity also, in an operation such as is conducted by AVCO R.A.D. wherein recourse is had to IBM tabulation of all instrumentation. Accordingly, by referring to Table 4, the reader is enabled to interpret the letter coding under the column heading "Manufacturer". (Mention of manufacturer does not imply endorsement; other manufacturers can supply similar instruments.)

No attempt is made herein to detail the application of any instrumentation. This subject is more suited to presentation in volume form since the information is vast.

For further information on implementing standards activities, no better sources are available for literature than the established manufacturers listed in Table 4.

The reader also is referred to articles which have appeared in *Instruments and Control Systems* such as "Equipment for a Standards Laboratory" by Kidwell —November 1957; "Setting up a Standardization Laboratory" by Greenspan and Reece—January, 1959. In fact, the entire *I&CS* issues of January 1959 and September 1959 should be on file in a standardization activity, in addition to the *IRE Transactions on Instrumentation*, Vol. I-7, December 1958, No. 3 & 4, in which appears the papers presented at the 1958 Boulder Conference on Electronic Standards and Measurements.

(Following articles will describe AVCO's physical and electro-mechanical standards, including temperature, pressure, mass, humidity, sound, vibration, density, specific gravity, length, surface, etc.)

TABLE 3—INSTRUMENTATION LIST

Note: Mention of company does not mean endorsement. Instruments are available from several sources. The user should check all sources for latest developments.

ITEM	MANUFACTURER AND MODEL	APPLICATION
Amplifier, Decade	BAA 220-B	E0
Amplifier, Detector	GEB 1231B	E28
Amplifier, Freq. Converter	HEA 525A	E0, R0
Amplifier, Standing Wave	PRD 277A	R0
Amplifier, Unit	GEB 1206B	E0
Analyzer, Spectrum	POB SA 84	R4
Attenuator, Calibrated-Prec.	HEA P382A, H382A, X382A	R12, 18
Attenuator, Coaxial Fixed	PRD 1100A, B, C	R0
Attenuator, Level Set	PRD 156B, 162B, 158B, 159B	R0
Attenuator, Level Set-mm	PRD 193, 179	R0
Attenuator, Precision-Dial	WAB 483	E0
Attenuator, Precision Gauge	PRD 195-B, 178-B, 188-B, 153-B, 192-A 185-B	R18, 12
Attenuator, Precision-Var.	PRD 150A	R18
Attenuator, W. G. Fixed	NAB 718-3, 718-6, 722-3	R0
Attenuator, W. G. Fixed	PRD 140B, C, 138B, C	R0
Attenuator, W. G. Var.	NAB Q727	R0
Attenuator, Var. Cutoff	PRD 198	R0
Attenuation Test Set	WEA VM-1B	R17, 18
Batteries, Nickel Cadmium	SOG 5-60M220	E0
Bolometer	PRD 634	R13
Bolometer, Tunable	MIH MA 599	R13
Box, Constant Temperature	EPA	E3, 1
Bridge, Anthony Pattern	LEA 4230	E16, 8
Bridge, Inductance	GEB 667A	E30
Bridge, Kelvin - Adj. Std.	LEA 4300	E17
Bridge, L-C Precision	ROG FT-LCB	E32
Bridge, Power	WEA PB-1	R18, 14
Bridge, Precision Wenner	EPA	E11
Bridge, RF	GEB 1606-A	R0
Bridge, Thermistor	WEA TB-2,-3	R18, 14
Calibrator, AC Meter	RAH 261-B	E20, 21
Calibrator, DC Meter	RAH 260-C	E20, 21
Calivolter	CAB A23	E0
Calorimeter, Dry	PRD 666	R4, 15
Capacitor	GEB 505, L, M, G	E0
Capacitor, Decade	LEA 1091	E27
Capacitor, Precision - Var.	GEB 722-D, NQ, MEQ	E26
Capacitor, Std.	GEB 1409, F, L, T, Y 509, F, G, K, L	E27, 28
Capacitor, Standard	JAE D51, A1, A2, A4, A5, C11, C12, C13, C14, C21, C22, C23, C24, D31, D32, D33, D34, D41, D42, D43, D44	E26, 28
Capacitor, Std. Air	GEB 1401-A, B, C, D	E27, 28
Capacity Measuring Assembly	GEB 1610A	E28
Cathetometer	GAA	E0
Cell, Std. Volt - Sat.	EPA 101G	E3, 1
Cell, Std. Volt - Unsat.	EPA 100, 103	E0
Cell, Std. Volt - Unsat.	WEC 4	E4
Charger, Battery	HEB BE4	E0
Charger, Battery	MAB VA400	E0
Comparator, Standard Cell	EPA	E2
Counter, Electronic	BEC 5571	E0, R0
Counter, Electronic	HEA 524B	R2
Coupler, Directional	HEA G752D, X752D	R0
Coupler, Directional	MIH 662A, 1036A, C	R0
Coupler, Directional-W.G.	NAB 3001-30, 1029-20, 1068-10	R0
Coupler, Directional-W.G.	PRD 413, 411	R0
Delay Line, Variable	ADA 2011	E0
Delay Line, Variable	ADA 605D, 505, 506	E0
Detector, Discriminator	GEB 1210P-1	E0
Detector, Null	GEB 1231-B	E0
Detector, Phase	ADA 205A	E0
Detector, Standing Wave	MIH 1022-A	R5
Detector, Standing Wave	PRD 204B	R12, 5
Detector, W. G. Tunable	NAB Q507, E507, M507	R4
Detector, W. G. Tunable	NAB 510, 512, 513	R6
Detector, VSWR	PRD 219	R5
Filter	ALD 2-B	R1
Filter	GEB 1951A	E0
Filter, Adjustable	GEB 1231P-2, 3	E0
Filter, Adjustable	GEB 1231P-5	E28
Filter, RF	FIL FSR-202	R11
Frequency Divider	SCJ ND5, NDF2	R1
Frequency Divider + Clock	HEA 113AR	R1
Galvanometer	LEA 2420B	E6, 7
Galvanometer	RUA 3417	R14
Galvanometer, HS Reflecting	LEA 2284-C, 2284-D	E6
Galvanometer, HS Reflecting	LEA 2284-X	E11
Galvanometer, Reflecting	LEA 2500-C	E2
Galvanometer, Reflecting	RUA 3202	E0
Galvanometer, Reflecting	RUA 3451H	E0
Galvanometer, Spotlight	LEA 2430-A, C	E0
Galvanometer, Spotlight	RUA 3402	E0
Generator, Harmonic	MIH MA435	R11, 12
Generator, Harmonic	NAB QE-577, VM-577	R11, 12
Generator, Noise	AIB 79B, 48, 49, 50, 51, 52	R11, 12
Generator, Oscillator	HEA 650A	E0
Generator, R-C Oscillator	GEB 1210B	E30, 32
Generator, R-C Oscillator	GEB 1302A	E28
Generator, R. F	WEA MS-12, 13, 8, 9, 10, 11	R18
Generator, Reference	BEC 5580	R0
Generator, Signal	GEB 1303A	E0
Generator, Signal	HEA 614A, 616A, 618B, 620A	R0

ITEM	MANUFACTURER AND MODEL	USE
Generator, Square Wave	HEA 211A	R0
Generator, Standard Signal	GEB 1001A	R1
Indicator, Null	MIC 104WIG	E0
Inductor, Decade	SHB 1210	E0
Inductor, Standard	GEB 1482 B, C, D, E, F, G, H, J, K, L, M, N, P, Q, R	E29
Inductor, Standard	LEA 1531, 32, 33	E31
Inductor, Standard	SUD 6720, 7634, 7711, 6776, 6916, 6915, 7666, 7717, 6314, 7709	E29
Inductor, Standard	SUD 7658, 7550, 7660, 7506, 7723, 7540, 7649, 7564, 7560, 7671, 7527, 7536, 7524, 7664	E31
Isolators, Ferrite	PRD 1203, 4, 5	R18, 12
Interpolator	GED AM-1	R1
Inverter	BRK 4610	E0
Lab Jacks	CEH 19086, 19089	E0, R0
Line Stretcher	MIL SR-500M, F, 1500F, M	R0
Load, W. G. Sliding	PRD 1132, 1131, 1133, 1115, 1116, 1121	R0
Magnet, Standard	RAB 721	E0
Meter, Ammeter	WEB PX-14	E0
Meter, Ampere	WEC 326	E20
Meter, Electrostatic	SEA ESH	E23
Meter, Frequency	NAB Q 807, M807, E807	R4
Meter, Frequency	NAB 809, 810, 812	R4, 12
Meter, Frequency	MIH 506A, 518A, 588, 671	R4
Meter, Frequency	FRD 3545-3, 4458-3, 5882-1, 8397-1, 9611-1	R4, 12
Meter, Flux	SEA FM	E0
Meter, Microwave Watt	WAK U-182	R4, 16
Meter, Microwave Watt	WEC Engen 1493 + 1594	R4, 14
Meter, Microampere	SEA S	E2
Meter, Milliamp	WEC 622	E0
Meter, Milliamp	WEC 931	E2
Meter, Milliamp DC	MIB MV-17C	R0
Meter, Phase	ADA 405	E0, R0
Meter, RX	BOA 250A	
Meter, Transfer AC/DC	ENA	E9
Meter, Volt	WEC 326	E21
Meter, VTVM	BAA 310A	E0
Meter, VTVM	HEA 400H, 410B	E0, R0
Meter, Watt	WEC 326	E22
Meter, Wave	FRD 12150-1, 15180-1	R4
Mismatch, Standard Prec.	PRD 1401-A, C, E; 1402-B, D, E, C, A; 1403-A, C, E; 1406-A, B, C, D, E; 1407-A, B, C, D, E; 1405-A, B, C, E	R18
Modulator, Power Supply	WEA MO-3	R18
Mount, Bolometer - Coax	PRD 627A, 628A	R18
Mount, Crystal	MIH 1028AR	R6
Mount, Crystal W. G.	PRD 601, 616A, 621A, 615, 6604, 6605, 6606	R6
Mount, Crystal W. G.	WAB 615, 714	R6
Mount, Bolometer - mm	PRD 632	R13
Mount, Bolometer - W. G.	PRD 620, 618,, 618F1, 620F1	R13
Mount, Bolometer, Tunable	NAB 510	R13
Mount, Thermistor-Tunable	MIH 599	R13
Mount, Crystal - Tunable	MIH 539C	R6
Mount, Thermistor - Coaxial	WEA	R18
Mount, Thermistor - X-Band	WEA	R18
Multiplier, Frequency	GED FM4-A	R1
Multiplier, Std. Frequency	GEB 1112A, 1112B	R1
Oscillator, Time Calibrator	GEB 1213-C	E0
Oscillator, Transfer	HEA 540	R1
Oscillograph	OFA 504	E0
Oscilloscope	HEA 130A	E0, R0
Oscilloscope	TEA 545	R1
Oscilloscope, Comparison	GEB 1109A	R1

ITEM	MANUFACTURER AND MODEL	USE
Peak Voltage Unit	SEA VPA	E23
Potentiometer	HEM T-10-A	E0
Potentiometer, Brooks Defl.	WIF 7	E0
Potentiometer, Wenner	LEA 7558	E6
Potentiometer, Thermofree	RUA 2768	E5
Power Divider	MIL DP-3, 4, DB-3, 4	R4
Power Supply	AIB 71	R12
Power Supply	GEB 1201A	E0
Power Supply	SOA VIRSAC 750	E18
Power Supply, DC	EPE VR607	E18
Power Supply, DC	FLA 406	E18
Power Supply, DC	RSA	R0
Power Supply, HV	BEI 8050/50-10	E18
Power Supply, Klystron	FXR Z817A	R0
Probe, Broadband	PRD 250A, 253	R18, 4, 12, 5
Q Standard	BOA 518, A1, 2, 5	R9
Ratio Box, Kelvin Bridge	LEA 4320	E17
Ratio Set, Double	LEA DB21782	E15
Ratio Set, Wenner	LEA 4392	E14
Receiver + Preamp	AIB 130, 130B	R12
Receiver, Radio	NAD HR0 60R	R0
Receiver, Radio	SPA WWVC	R1
Resistor, Decade	GEB 1432M, K, P	E0
Resistor, Decade	GRA E-1042, 1045	E0
Resistor, Decade	JUA DMR-105	E19
Resistor, Shunt	LEA 4390	E8
Resistor, Standard	GEB 500K M, X, L	E0
Resistor, Standard	GRA E-1323, 22, 1230, 35, 43, 44, 45, 46, 47	E13
Resistor, Standard	LEA 4020B, 4025B, 4030B, 4035B, 4040B	E12
Resistor, Standard	LEA 4210	E10
Resistor, Standard	LEA 4221B, 4222B, 4223	E12
Resistor, Standard	WOD 323-4W, 5W, 6W, 7W, 8W, 9W, 3W, 2W, 1W	E13
Short, Variable	MIL SO-300F, M; SO-1000F, M	R0
Short, Waveguide-Adj.	LID 1362, M2	R0
Short, Waveguide-Adj.	WAB 661, 761	R0
Short, W. G. Sliding	PRD 321A	R0
Shunt, Ayrton	LEA 2167	E0
Shunt, Box	GRA E-1330	E8
Slide Wire	LEA 4258	E0
Slotted Section - Coax.	PRD 205A, 215A	R4
Slotted Section, mm	PRD-216B	R18, 5
Slotted Section, Prec. W. G.	PRD 210B, 203D, 211B, 204B, 201A	R5, 18, 4, 12
Standard, Time and Frequency	NOB 110	R1
Termination, Coaxial Fixed	NAB 371, 370	R0
Termination, Coaxial Sliding	NAB 372	R0
Termination, W. G. Fixed	NAB E297	R0
Termination, W. G. Fixed	PRD 131A, 132A, 133A, 121A, 116A, 1103	R0
Termination, W. G. Sliding	NAB E377	R0
Thermo-Humidigraph	BRC F4069TH	E0
Thermometer, Lab. Glass	CEA 0-105°C	E0
Transformer, Constant Volt	SOE 23-13-150	E0
Transformer, Current	WEC 327	E24
Transformer, High Voltage	BEI	E18
Transformer, Standard Ratio	GED PT-2, PT-5	E25
Transformer, Voltage	WEC 311	E25
Transition	PRD 3388, 3389	R0
Tuner, Double Stub	NAB 903	R0
Tuner, Double Stub	WEA DS-109	R0
Tuner, E-H	LID 26-K2, L2, M2	R0
Tuner, E-H	PRD 314A, 312A, 313A	R0
Tuner, E-H mm	AIJ 171-V	R0
Tuner, E-H mm	MIH MA598A	R0
Tuner, E-H mm	NAB E957	R0
Tuner, E-H mm	PRD 323	R0
Tuner, Slide Screw	WAB Series, 783, 883	R0
Tuner, Stub	WEA 681	R0
Volt Box	LEA 7591, 7581	E8
Voltage Divider	RUA 8952	E19
Voltage Divider, Decade	GEB 1454A	E0
Voltage Reference Source	EPE VR-607	
Voltage Reference Source, AC	SOA VRS AC 750	E25
Voltage Regulator	CUB 702619	E0
Voltage Regulator	SOA MV-RH 500	R1

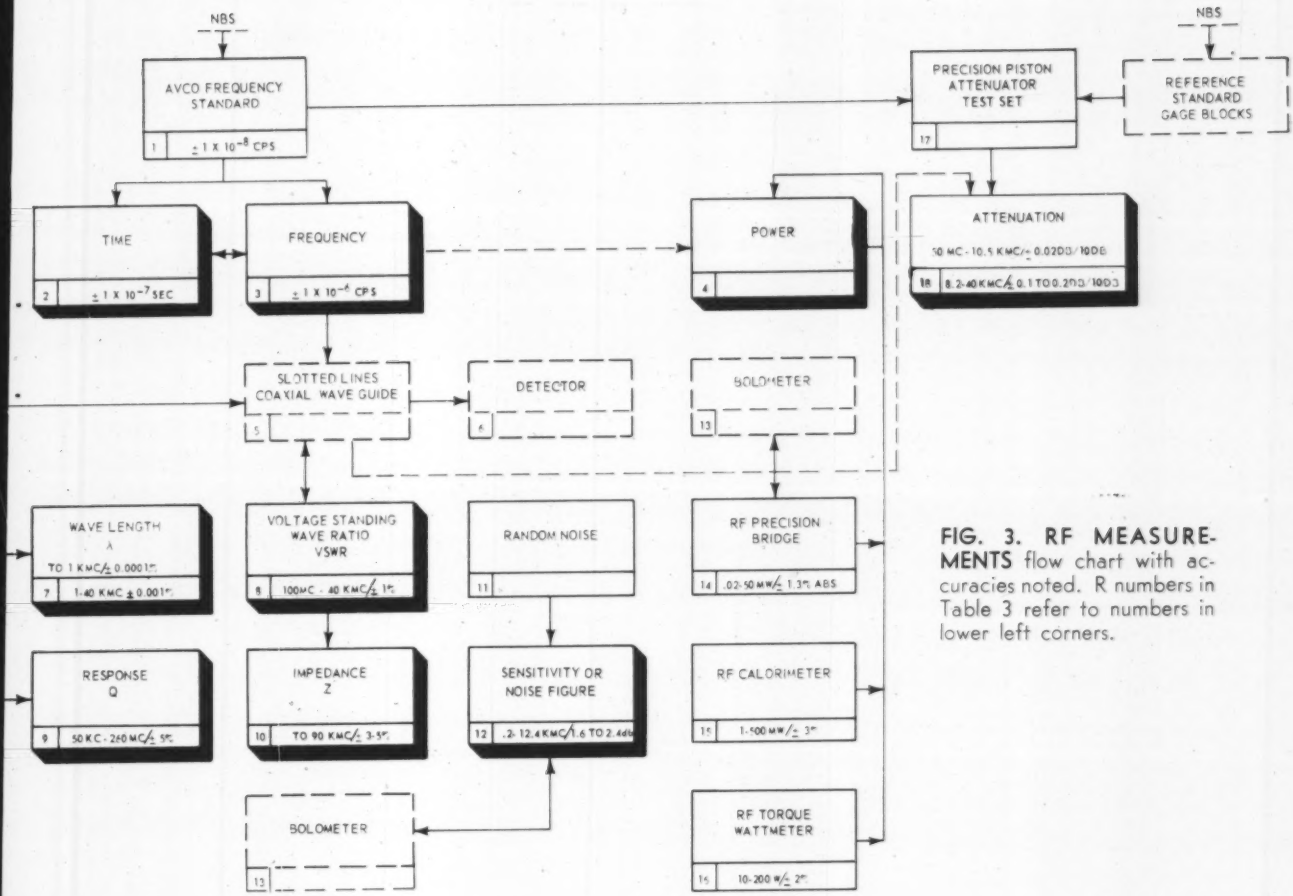
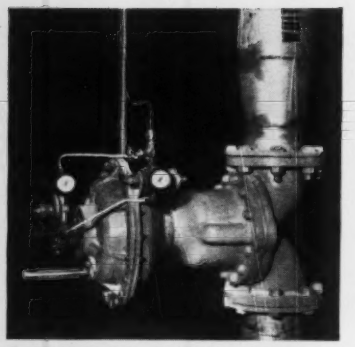


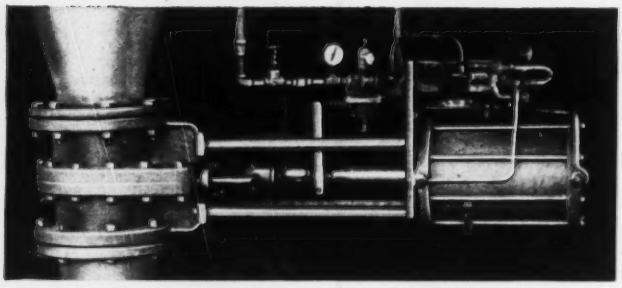
FIG. 3. RF MEASUREMENTS flow chart with accuracies noted. R numbers in Table 3 refer to numbers in lower left corners.

TABLE 4—CODE OF MANUFACTURERS

ADA—AD-YU (Advance Electronic), Passaic, N. Y.
AIB—Airborne Instrument Lab., Mineola, N. Y.
AIJ—Aircom, Winthrop, Mass.
ALD—Allison Labs, Inc., La Puenta, Calif.
BAA—Ballantine Labs, Boonton, N. J.
BEC—Berkeley Div./Beckman, Richmond, Calif.
BEI—Beta Electric Corp., S. Norwalk, Conn.
BOA—Boonton Radio Corp., Boonton, N. J.
BRC—Bristol Co., Waterbury, Conn.
BRK—Bruel & Kjaer, Cleveland, Ohio
CAB—Calidyne Co., Winchester, Mass.
CEA—Central Scientific Co., Chicago, Ill.
CEH—Cenco Lerner, Cambridge, Mass.
CUB—Curtiss Wright/Electronic Div., Carlstadt, N. J.
ENA—Engleinard, Charles Inc., Newark, N. J.
EPA—Eppley Labs, Inc., Newport, R. I.
EPE—Epsco, Inc., Boston, Mass.
FIL—Filtron Co., Flushing, Long Island, N. Y.
FLA—Fluke Mfg. Co., Inc., Seattle, Wash.
FRD—Frequency Standards, Inc., Asbury, N. J.
FXR—F. R. Machine Works, Inc., Woodside, N. J.
GAA—Gaertner Scientific, Chicago, Ill.
GEA—General Electric Co., Schenectady, N. Y.
GEB—General Radio Co., W. Concord, Mass.
GED—Gertsch Products, Los Angeles, Calif.
GRA—Gray Instrument Co., Philadelphia, Penna.
GRE—Greibach Instruments Corp., New Rochelle, N. Y.
HEA—Hewlett Packard Co., Palo Alto., Calif.
HEB—Heath Co., Benton Harbor, Mich.
HEM—Helipot Div./Beckman, Newport Beach, Calif.
JAE—Jahre, Richard, Germany
JUA—Julie Research Labs., New York, N. Y.
LEA—Leeds & Northrup, Philadelphia, Penna.
LID—Lieco Co., Inc., Oceanside, Long Island, N. Y.
MAB—Mallory, Indianapolis, Ind.
MIB—Millivac Instrument Corp., Schenectady, N. Y.
MIC—Minneapolis-Honeywell, Philadelphia, Penna.
MIH—Microwave Assoc., Inc., Burlington, Mass.
MIL—Micro Labs., Livingston, N. J.
NAB—Narda Corp., Mineola, N. Y.
NAD—National Co., Inc., Malden, Mass.
NOB—Norrman Labs, Ernest, Williams Bay, Wisc.
OFA—Offner Electronics, Inc., Chicago, Ill.
POB—Polarad Electronics Corp., Long Island City, N. Y.
PRD—Polytechnic Research/Development Co., Brooklyn, N. Y.
PRL—Physics Research Laboratories (see WOD), Hempstead, N. Y.
RAB—Rawson Electrical Instrument Co., Cambridge, Mass.
RAH—Radio Frequency Labs, Inc., Boonton, N. J.
ROG—Rohde & Schwarz, Germany
RSA—R S Electronics Corp., Palo Alto, Calif.
RUA—Rubicon Co., Philadelphia, Penna.
SCJ—Schomandl, Munich, Germany
SEA—Sensitive Research Instrument Corp., New Rochelle, N. Y.
SHB—Shasta Div./Beckman, Richmond, Calif.
SHC—Sheffield Corp., Dayton, Ohio
SOA—Sorensen Co., Inc., Stamford, Conn.
SOE—Sola Electric Co., Chicago, Ill.
SOG—Sonotone, Elmsford, N. Y.
SPA—Specific Products Industrial Elec., Sherman Oaks, Calif.
SUD—Sullivan & Griffiths, London, England
TEA—Tektronix, Portland, Oregon
WAB—Waveline, Inc., Caldwell, N. J.
WAK—Wayne Kerr, Chicago, Ill.
WEA—Weinschel Engineering, Kensington, Md.
WEB—Westinghouse Electric, Pittsburgh, Penna.
WEC—Weston Electrical Instrument Corp., Newark, N. J.
WIF—Winslow, Union, N. J.
WOD—Wolff, Otto (see PRL), Germany

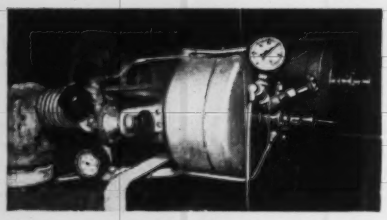


SAUNDERS VALVE (Conoflow close-coupled type) affords automatic throttling control of white water in bleach plant at Marathon Southern's Naheola, Alabama mill. Conoflow is the world's largest producer of Saunders valves for automatic control.



PULP STOCK VALVE (8" Walworth with Conoflow actuator) on automatic control service at Crossett Paper Mills, Crossett, Arkansas. Conoflow actuated pulp stock valves are available in all sizes.

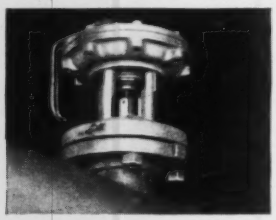
CONOFLOW
CONTROLLED FLOW
AUTOMATION IN PAPER MAKING



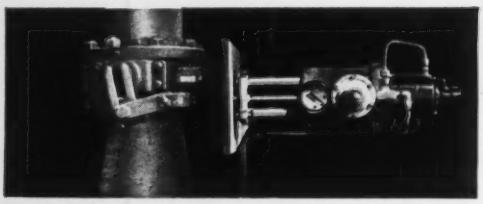
CONTROL VALVES (Conoflow Series LB) on a tough service at the R-W Paper Company plant in Longview, Washington. These 2" single-seated angle valves are handling steam at 700° F. and 600 psi with a 580 lb. pressure drop.

The installations shown here are typical of how Conoflow final control elements have helped bring automation to the pulp and paper industry. Conoflow products make possible faster, more efficient operations, and substantial savings of costly process fluids for many modern paper mills.

VALUABLE DATA FREE! To find out where automatic process control can help you, write for Bulletin MD-1 *Application of Conoflow Equipment in Modern Pulp and Paper Making Processes.* Also ask for reprint *How to Use Standard Pulp Valves for Throttling Control*—a thought-provoking and informative article. Both will be mailed to you promptly, without obligation. Dept. C-901, Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. Conoflow engineering representatives are located in principal cities throughout the world.



PRESSURE TRANSMITTERS (Conoflow Model P) measuring pressure of pulp stock during bleaching process at the P. H. Glatfelter paper plant in Spring Grove, Pa. This is one of several Conoflow Model P's measuring pressure and liquid level at this mill.



BUTTERFLY VALVE (Conoflow actuated) on automatic control service at Crossett Paper Mills, Crossett, Arkansas.

CURRENT CONTROLLERS (Conoflow Model EB) regulating speed of washer thickeners in bleach plant at Marathon Southern mill in Naheola, Alabama. The Model EB is a unique pneumatic-electric transducer—a Conoflow exclusive for the paper industry.

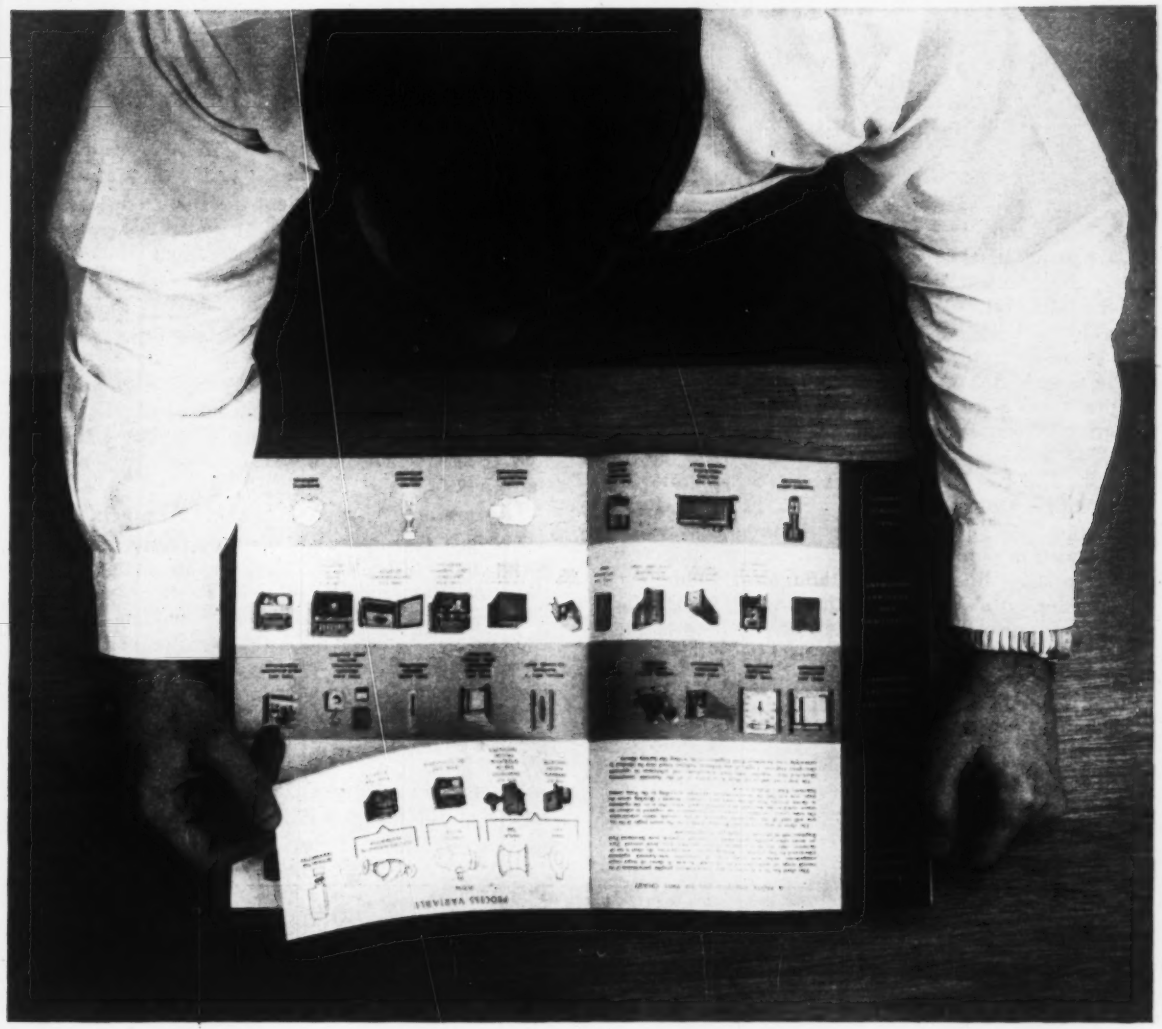
CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

SUBSIDIARY WALWORTH

CIRCLE 64 ON READER-SERVICE CARD

WHAT'S THE HARDWARE SITUATION IN ELECTRONIC PROCESS CONTROL?



THIS NEW BOOKLET SHOWS YOU

Here, in concise, graphic form, is the whole array of Swartwout Autronic® instrumentation, industry's most comprehensive system of electronic process controls. Here is a unique presentation that shows you at a glance the diversity of equipment available to you, from sensor to actuator, for any given variable. Whether you're pondering a simple flow-control set-up or an interlocked multi-loop system, Swartwout has the hardware for the job—and this booklet will give you the specifics. To get a copy, just write for Bulletin A-913, "A Functional Guide to Autronic Control Equipment." SWARTWOUT DIVISION, CRANE CO., *Hooksett Industrial Park, Manchester, New Hampshire.*

CIRCLE 65 ON READER-SERVICE CARD

What Price Translation?

JOHN McLEOD,
Convair-Astronautics

IN the June 1958 issue of this publication there was an article, "What Price Computer Reliability," by Stanley Rogers (Convair-San Diego) and John McLeod (Convair-Astronautics).*

This article was subsequently translated into Russian and published in "Express Information of the GNTK SSSR, Akademiya Nauk All-Union Institute of Scientific and Technical Information. Series: Computing Technique. Division: Generall."**

Mr. E. Gros, Managing Director of Scientific Information Consultants Ltd. (661 Finchley Road, London NW2) who collect and process scientific information published in various foreign languages, particularly Russian, was thoughtful enough to send the authors a copy of the Russian translation.

Being curious, I asked our Convair-Astronautics translator, Mr. W. R. Eichler, to give me as literal a translation of the Russian version as possible. I then compared the resulting re-translated English version with the original article and found:

1. In general the sense of the article was preserved.
2. Most of the facts and figures survived and were correct.
3. Discussion and comment were deleted, leaving the facts and figures in some cases out of context, and therefore subject to interpretations other than those intended.
4. Neither the authors nor *Instruments and Automation* (now *Instruments and Control Systems*) was mentioned.
5. The title became "Analysis of the Operating Reliability of Systems of Electronic Computers".
6. "Convair-San Diego Analog Computer Laboratory" became "The Model Laboratory of Convair-San Diego".
7. Amplifier "choppers" became "contacts".

The last two items are the only ones which are technically misleading. Certainly an analog computer can be used to create an electronic model, but it is a very special kind of model. "Model Laboratory" conveys an entirely different idea, at least in this country.

And though "choppers" are essentially electrically-driven "contacts" they are also very specialized devices, not at all adequately described as contacts.

Mr. Eichler tells me that both "model" and "contact" were literal translations of the Russian words.

*Volume 31, No. 6, pp 1039-1041.

**March 1959, No. 9, pp 33-36; VT-36.

INDUSTRY CALIBRATION SURVEY

The table given here lists the results of a survey made by the Aerospace Industries Association on the question of calibration and standards in the field of electrical measurements. Sixty eight firms (most with over 500 employes) were surveyed.

In general, there are major problems in less than half of the subcategories listed in this section of the questionnaire. Some of the major problem areas, judged from the number of organizations which reported problems in these areas, are the measurement of AC voltage from 1 to 300 volts, the measurement of DC resistance of standard resistors, the measurement of DC voltage with digital voltmeters, and the measurement of the DC voltage ratio of standard voltage dividers. The number of organizations having problems in the subcategories in this section varies from 0% of the 9 organizations replying to the "Residual Phase Angle in AC Resistance Measurements" to 33% of the organizations replying to the "Pulse Voltage" subcategory.

Question:
If your standards are *not* calibrated by a *higher level* source outside of your company, please indicate what means are used; indicate more than one if applicable.

Answers:
10 Round-robin cross checks with standards of similar quality in your own company.
2 Round-robin cross checks with standards of

similar quality in organizations outside of our company.

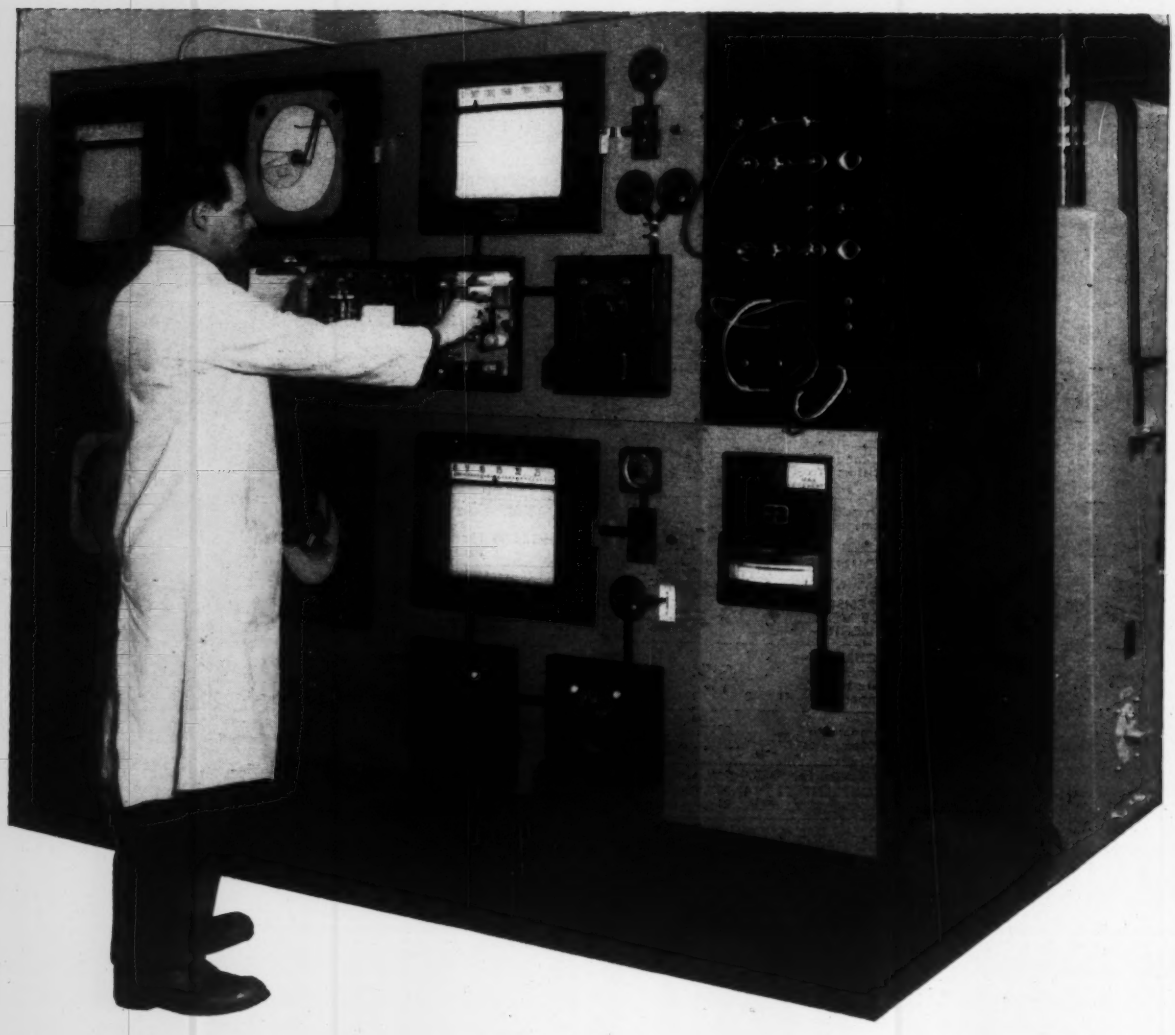
1 Theoretical calculation and/or error analysis.

11 Depend upon the manufacturer's original calibration when standard was purchased.

11 Calibration in terms of some other quantity or parameter represented by a standard of known accuracy.

1 Not interested in accuracy; only interested in repeatability, i.e., precision.

NATIONAL BUREAU OF STANDARDS			SUB-CATEGORIES OF MEASUREMENT	REPLIES INDICATE EXISTING ACCURACIES SUFFICIENT			
BEST ROUTINE ACCURACY	FREQUENCY RANGE	MAGNITUDE RANGE		YES	NO	PROBLEM ACCURACIES	
0.0005% 0.002% 0.01%		Thomas 1Ω .001Ω to 100,000Ω 0.0001Ω	DC RESISTANCE— Of Standard resistors	32	10	.0002% .0001% .002% .001% .01%	(1) (2) (2) (3) (2)
			Of product items	28	5	.005% .02% .01%	(2) (2) (1)
"NO MEASUREMENT"			RESIDUAL PHASE ANGLE IN AC RESISTANCE MEASUREMENTS—	13	0		
0.05%		1μ amp. to 1 amp	DC CURRENT— 1 microampere to 1 ampere	41	2	.001% .01%	(1) (1)
0.05%		1 amp. to 100 amps.	1 ampere to 100 amperes	38	5	.001% .01%	(2) (3)
0.05%	60 cps to 30 Kc	15 ma to 20 amps	AC CURRENT	22	4	1.0% .25% .01%	(1) (1) (2)
0.1% Ratio 3 Min. Phase Angle	60CPS	0.25 to 4000 amp	CURRENT RATIO OF CURRENT TRANSFORMERS—	19	3	.04% .05%	(1) (2)
0.0002%			DC VOLTAGE— Of saturated standard cells	13	4	10^{-4} 10^{-5} .0004 ±1μv	(1) (1) (1) (1)
0.01%			Of unsaturated standard cells	27	6	.00004% .005% .002% .001% 0.1%	(1) (1) (2) (1) (1)
0.01%			Of potentiometers	29	5	.005% .002% .001% .01% .10%	(1) (1) (1) (1) (1)
0.05%		1 mv to 1000 v	Of digital voltmeters	26	10	10^{-4} .005% .05% .01%	(2) (1) (6) (1)
			Of products items	31	5	.005% .03% .01% 1.0%	(1) (1) (2) (1)
0.05%		0.01 v to 1000 v	AC VOLTAGE— 1 to 300 volts, 20 to 10,000 cps	39	16	.1% .01% .02% .05% .001%	(2) (4) (3) (4) (3)
0.05%	30 Kc	600 v	Other voltage and frequency ranges	28	7	.01% .05% .10%	(1) (3) (3)
0.01%		1.5 to 1500 v	DC VOLTAGE RATIO— Standard voltage dividers	32	11	10^{-5} 10^{-6} .05% .01% .001%	(2) (2) (3) (3) (1)
			Products parts	14	1	.01%	(1)
0.01%	60c-10 Kc		AC VOLTAGE RATIO— Standard ratio transformers	27	2	.0001% .05%	(1) (1)
			Product parts	12	1	.15%	(1)
1%		High Voltage	PULSE VOLTAGE—	16	5	0.1% 0.5% 1.0%	(2) (2) (1)
1%		High Voltage	PULSE VOLTAGE DIVIDING RATIO—	4	1	1%	(1)
			CAPACITY VOLTAGE DIVIDERS FOR PULSE VOLTAGES—	11	2	0.1% 1.0%	(1) (1)
0.03% to 0.1%	60 100 400 1000 cps	100μh to 10h	INDUCTANCE—	39	6	.05% .01% .20% .10%	(1) (2) (2) (1)
0.5% 0.2%	0.1c to 10 Mc 50c to 100 Kc		DIELECTRIC PROPERTIES OF MATERIALS— Dielectric constant	12	0		
5% +0.0005 1% +0.00005	0.1c to 10 Mc 50c to 100 Kc		Loss tangent	4	0		
1%		7000 g	MAGNETIC FLUX DENSITY— Permanent magnets	19	0		
1% (Could be improved if justifiable)			Solenoids	9	0		
0.25%			Search coils	15	1	5%	(1)
Fluxmeters 2%			Product parts or assemblies	9	0		
2%-5% (Could be improved if justifiable)		0 to 2000 oersted	DC PERMEABILITY—	6	0		
5-10%	60 cps	0 to 15,000 gauss	AC PERMEABILITY—	7	0		
			COMPLEX AC PERMEABILITY—	3	0		
2-5%	—60 cps	19,000	AC CORE LOSS	4	0		
0.03% to 0.1%	60 100 400 1000 cps	100 pf to 1μf	CAPACITANCE— Of fixed capacitance standards	29	11	.10% .05% .02% .01% .002%	(1) (2) (3) (3) (2)
0.03% to 0.1%	same as above		Of variable capacitance standards	24	6	1.0% 0.1% .05% .01% .001%	(1) (1) (2) (1) (1)
			Product parts	21	2	.01% .05%	(1) (1)
0.05 to 0.1%	DC to 1000 cps	0.1 to 100 amps 30-1000v	POWER—	30	6	.01% .05% .1% .25%	(2) (2)
0.1 degree (Could be improved if justifiable)	400 cps	360°	PHASE ANGLE— With phase meters	31	3	.50° .10° .010°	(1) (1) (1)
			Of phase signal generators	9	1	.01°	(1)
			Q— Of standard Q coils	22	4	1.0% .05%	(2) (2)
			Of product parts	13	2	1%	(2)
			PULSE WAVEFORM AND DELAY— Pulse width	19	3	1 millimicro sec. .01μ sec.	(1) (2)
			Delay on delay lines	12	2	1 millimicro sec. .01μ sec.	(1) (1)



Electronic, nuclear ceramics development at Westinghouse aided by flexible temperature control panel

Bristol Round-Chart Program Controller, Double-Range Controller, Strip-Chart Recorder and Free-Vane Controller are tied into panel patchboard

This instrument panel was designed by Westinghouse to give utmost versatility in furnace control at the Ceramic Materials Laboratory of Westinghouse Electric Corporation, Pittsburgh, Pa.

Furnaces controlled here are used in development of ceramic materials, such as nuclear fuels, thermistors, ferrites, ceramic resistors and other specialty ceramics. These range from low-temperature (only 1000° F) short cycles to high-temperature (up to 3000° F) cycles involving three soaks over a 72-hour period.

Advanced research and development projects like this are just *one* of the areas where Bristol instruments are playing an outstanding role in modern ceramics. For ceramic production, Bristol makes a complete line of measuring, indicating, recording and automatically controlling instruments—plus a complete line of thermocouples and accessories. They're performing such vital jobs as preheat and cooling zone recording, high-temperature zone control (electric or pneumatic), draft control and car-pusher recording on tunnel kilns and automatic temperature program control and program scanning control on periodic kilns as well as many others.

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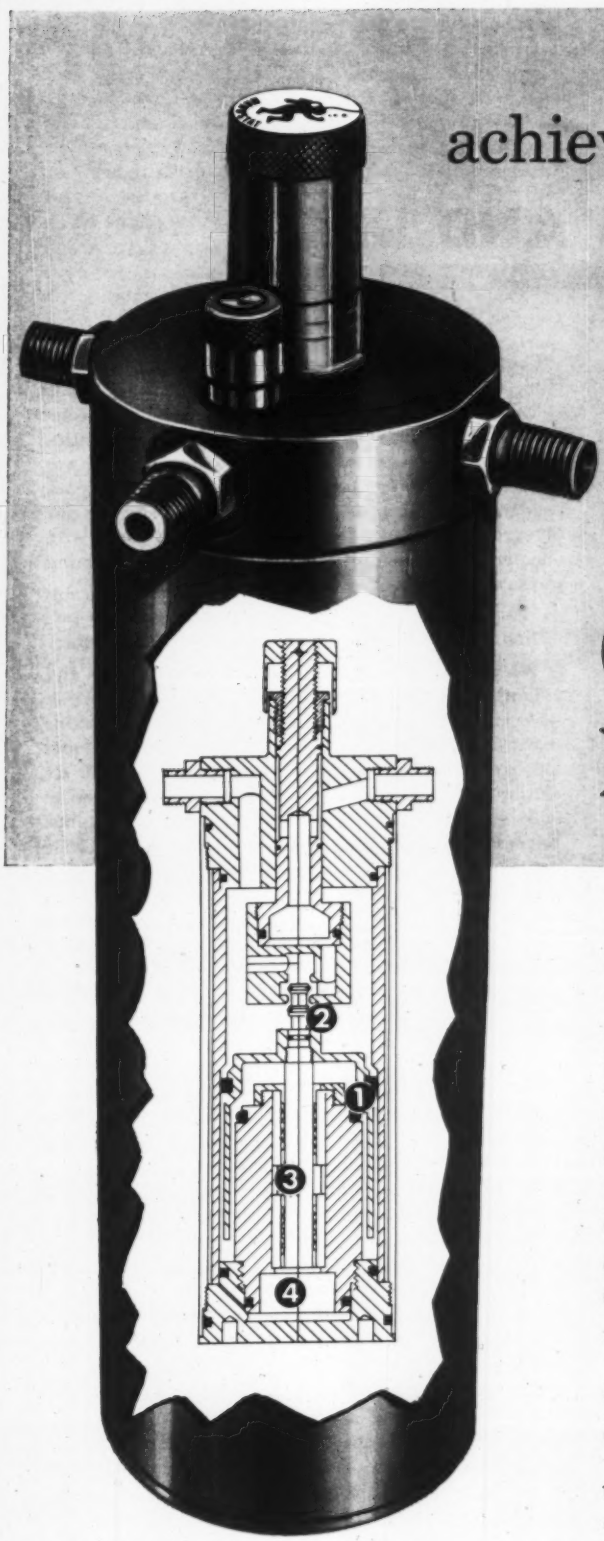

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HIGH CAPACITY • HIGH SENSITIVITY • HIGH RANGE

1. **Memory feature** for both vacuum and pressure. Once the vacuum or pressure is set in the Manostat, closing down system will not disturb the setting.
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Fields of Application

- **CHEMICAL**—Distillation, Evaporation, Reaction Vessels
- **INSTRUMENTS**—High precision pressure calibration, constant pressure or vacuum chambers, precise flow control in gaseous systems.
- **FOOD AND PHARMACEUTICALS**—Precise control for distillation of sensitive materials.
- **AVIATION**—Calibration of precision instruments

15085 Cartesian Manostat #10 complete and ready for use but with mercury. **$350.00**

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STANDARDS AND UNITS

A. G. McNISH
National Bureau of Standards

THE AUTHORS of the metric system intended that the meter should be one ten-millionth of the length of the north polar quadrant of the Paris meridian, demonstrating a desire that a measuring system be based on some natural magnitude which would remain constant, a desire which still exists with metrologists. But they soon found that they could compare two meter bars with each other with greater precision than they could relate them to the earth's quadrant.

Similarly, they found that the masses of two metal cylinders weighing about one kilogram each could be compared with each other more precisely than either could be related to the mass of 1000 cubic centimeters of water, which was supposed to define them. Thus, the pioneers in precise metrology found that greater precision in measurement could be achieved if they adopted some readily measurable artificial things for standards than if they adopted less readily measurable things of nature.

Accordingly, the International Commission of the Meter, meeting in 1872, resolved to take the meter in the Archives of Paris "as is" (*dans l'etat ou il setrouve*) for the standard of length. Similarly, they adopted the platinum-iridium kilogram of the Archives as the standard of mass.

Three years later many of the leading nations of the world signed the treaty of the meter which created a procedure for coordinating the standards of measurement for the scientific world through an International Bureau of Weights and Measures and a General Conference of Weights and Measures.

For many years no new standard for time was adopted, the ancient definition of the second as 1/86,400 part of a mean solar day being retained.

A separate and independent standard for temperature measurements was adopted and changed a number of times until, in 1954, the thermodynamic temperature scale was based on the triple-point temperature of water as 273.16°K. Other units were defined in terms of the units embodied by these standards by agreed-on equations of physics.

Four, and four only, independent standards have been adopted to which we attach the name *prototypes* —length, mass, time and temperature. The reasons for this are clear. They are standards for quantities which can be measured very accurately and they are standards which we believe can be preserved or reproduced very accurately. Furthermore, standards for other quantities can be constructed from them with adequate accuracy in accordance with the defining physical equations.

From Prototypes to Electricity Standards

We could establish our standards of electricity and magnetism with the same degree of arbitrariness that we used for the prototypes. However, it is not desirable that we do this because then the units of electrical and mechanical power would not be the same unless we clutter up the equations of electricity and magnetism with an unnecessary number of numerical constants. Furthermore, standards for the more useful electric quantities may be established in terms of the prototype standards with great accuracy, as shown by Silsbee.

In the early days of research in electricity and magnetism, there was no way to measure these phenomena accurately. The strength of a current was measured by the deflection of a compass needle which the current produced, but, since the deflection depended on the strength of the earth's magnetic field, two observers in different places could not compare their results. Variations in the strength of the geomagnetic field from place to place were measured by timing the oscillations of a "permanent" magnet which, even in those days, was known to be far from permanent.

C. F. Gauss first showed how magnetic and electric quantities could be measured accurately in terms of the units used for mechanical quantities which are embodied in relatively invariant standards. This is the well-known magnetometer experiment which every student of physics and electrical engineering must have performed. That Gauss thoroughly understood what he was doing we must presume. That he anticipated the reverence and mysticism with which future generations of scientists would regard the units of mass, length, and time is not likely. It is clear from the writings of those who followed him that they recognized a duplicity in electric units (esu) and magnetic units (emu).

Thus, in the early days of electromagnetic science, the systems of units were not on a satisfactory basis since electric and magnetic units were defined con-

Abstracts from paper in Proceedings of IRE, Vol. 47, No. 5, May 1959.

flictingly. Nor was the situation remedied by combining the esu and emu systems into that bifurcated system which falsely is called Gaussian. A further disagreeable feature is that some of the units in both systems are of inconvenient size, and are not even approximately equal to the units for voltage, current, and resistance which had been adopted by communications engineers.

To resolve these difficulties, Giorgi proposed that one more arbitrary unit and a standard for it, this time for an electric quantity, be added to the system. By suitably choosing this new unit, we can make the MKS units and the practical electrical units form a consistent system. What we mean by this is that equations of the type $W = I^2R$ would be valid if I and R were expressed in the electrical units and W is expressed in MKS units.

Giorgi's proposal found such increasing favor among scientists that in 1946 the International Commission on Weights and Measures adopted it in principle. But instead of adopting a new independent unit and a standard for it, they redefined the ampere (in accordance with another suggestion of Giorgi) in such a way as was equivalent to rewriting the equation for the force between two infinitely long current-carrying conductors.

The present-day system of electric units is known as the MKSA system. It is important to recognize that the unit for electric current (the ampere) does not occupy quite the same position in it as the meter, kilogram, and second, for the latter are prototype units and their values are fixed by their independent, proper standards. On the other hand, the value of the ampere is fixed in terms of the prototypes as given by an equation involving an arbitrarily adopted constant of proportionality.

We can measure all physical quantities directly in terms of the prototype standards, but following this procedure in all measurements is inconvenient, inaccurate, and imprecise. For this reason we construct standards for various derived physical quantities, and assign values to them in terms of the corresponding unit as derived by experiment from defining equations involved and the units fixed by the prototype standards. It is clear that, however carefully we perform the experiments in deriving these standards, they can never have the exactness inherent in the prototype standards.

Among the most accurate of the derived standards are those for some of the electric quantities. Because of this high accuracy and the convenience of making electric measurements, these standards are often used for measuring other quantities. We measure the heat of combustion of fuels, for example, by comparing the heat evolved when they are burned in a calorimeter with the known heat evolved by the passage of an electric current through a resistor. The results are given directly in joules, the internationally agreed-on unit for heat, but many chemists foolishly divide the results by 4.1840 to convert them to calories.

We can see how well our measuring system works in practice by examining how well various physical quantities can be measured in terms of the prototype standards. Several typical quantities are listed in Table 1, with estimates of the uncertainties involved in the best measurements of standards for these quantities at the National Bureau of Standards. The uncertainties are expressed in two ways, those of accuracy and those of precision. Under precision are placed the uncertainties in comparing two nominally identical standards for the quantity involved. Under accuracy are placed estimates of the uncertainties in relating the derived standards to the prototype standards. The uncertainties correspond approximately to "probable errors." No entries under accuracy are given for the meter, the kilogram, or the triple-point temperature of water since they are "accurate" by definition.

TABLE 1—ESTIMATES OF ACCURACY AND PRECISION IN MEASURING PHYSICAL AND ELECTRICAL QUANTITIES

Physical quantity	Device	Magnitude	Uncertainty in parts per million	
			Accuracy	Precision
Length	Meter bar	1 meter		0.03
	Gage block	0.1 meter	0.1	0.01
	Geodetic tape	50 meters	0.3	0.10
Mass	Cylinder	1 kilogram		0.005
	Cylinder	1 gram	1	0.03
	Cylinder	20 kilogram	0.5	0.1
Temperature	Triple-point cell	273.16°K		0.3
	Gas Thermometer	90.18°K	100	20
	Optical pyrometer	3000°K	1300	300
Resistance	Resistor	1 ohm	5	0.1
	Resistor	1000 ohms	7	1
	Resistor	0.001 ohm	7	1
Voltage	Standard cell	1 volt	7	0.1
	Volt box—standard cell	1000 volts	25	10
Power DC	Standard cell—resistor	1 watt	11	1.5
60 cycle	Wattmeter	10-1000 watts	100	50
X-band	Microcalorimeter	0.01 watt	1000	100

The table illustrates a number of interesting characteristics of our measuring system. The greatest precision is attained in measuring the quantities which have been selected as the basis of our system. In all cases illustrated except one, maximum precision is achieved when the magnitude of the quantity is the unit for the quantity. In all cases there is a decrease in accuracy for standards which embody a multiple or submultiple of the selected unit. Derived standards are subject to considerable inaccuracy, and this inaccuracy increases with the experimental complexity involved in relating them to the prototype standards. However, derived standards may be compared with similar ones with a precision far greater than the accuracy of the particular standard involved.

The maintenance and establishment of standards for all kinds of physical measurements is the basic responsibility of National Bureau of Standards. Fulfillment of this task requires development of precise measurement techniques and prosecution of basic research in most fields of the physical sciences. A standards program is not a static program. Growing technology requires more and more standards, extension of the range of existing standards, and improvement in accuracy.

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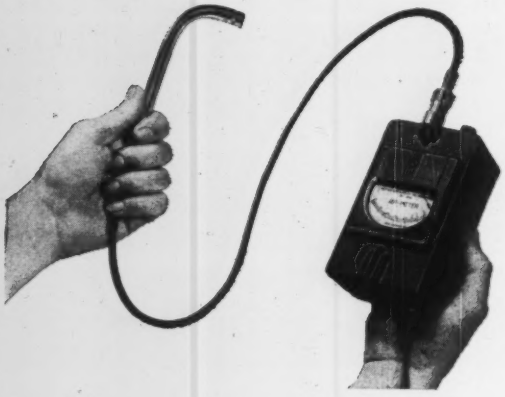

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CIRCLE 68 ON READER-SERVICE CARD

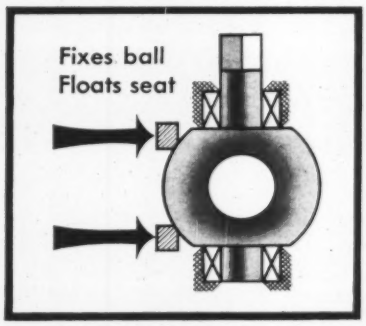
Can A Ball Valve Operate, Cycle After Cycle, With No Maintenance At All?

Read this remarkable answer, and discover an amazing engineering feat.

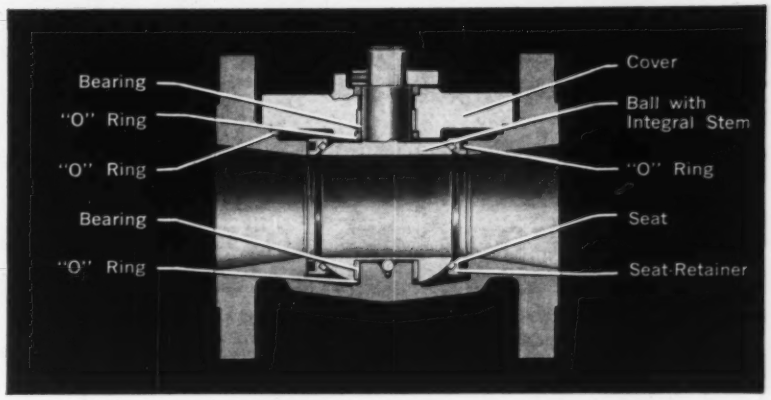
As most engineers know, ball valves offer a number of distinct advantages over all other types of valves . . . 90° on-off, minimum pressure drop, positive on-off indication, no lubrication, and compactness. In common with other valves, however, the design was insufficient to overcome the problem of continual maintenance.

Four years ago, this problem was faced by Hydromatics, Inc. in the valves that they produced for use in missiles, aircraft and ground support systems. Then, as today, all other ball valves were built with a ball that floated in its socket, and sealed by being forced against its seat by the pressure in the line. This caused seat distortion which made early replacement necessary.

Hydromatics tried a different approach. Rather than use the traditional floating ball, their engineers fixed the ball in bearings.



In the bearing-fixed **FLO•BALL** valve all pressure forces exerted on the ball are transmitted to low-friction bearings, thus eliminating down-stream seat distortion due to ball load. The pressure balanced seat, with its teflon sealing surface, is continually self-adjusted by the O-ring in the seat retainer.

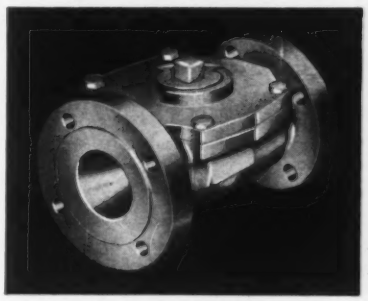


This O-ring acts as a self-energizing force that keeps the teflon seat always in contact with the ball. This insures positive sealing without seat distortion, and minimizes seat-resisting frictional forces. The combination of these low frictional forces results in low operating torque and extremely long seat life.

The bearing-fixed **FLO•BALL** valve proved itself immediately. Hundreds of missile and spacecraft systems, previously impossible, were made possible with these valves. The X-15, America's first manned space vehicle, for instance, has a Hydromatics **FLO•BALL** valve at its heart. Since its inception, the **FLO•BALL** has been used in more varied applications than all other ball valves combined.

Now, after the toughest application testing in history, bearing-fixed **FLO•BALL** valves are being mass produced for industry. They are available for off-the-shelf delivery to standard ASA dimensions in semi-steel, carbon steel, stainless steel, and aluminum. They operate at pressures to 600 psi, temperatures to 400°F and hold vacuum to 10^{-6} mm. of Hg!

The bearing-fixed **FLO•BALL** offers extra ball valve advantages. Top loading for easy access without removing the valve from the line, plus three features that are absolutely unique! Self-adjusting seats which automatically compensate for wear, proportional sealing force which automatically increases with line pressure, and the lowest torque, by far, of any valve. These combine to make the **FLO•BALL** valve virtually maintenance-free!



How long does it last without maintenance? Frankly, we don't know, since the first valves we ever built are still going strong and outlasting other valve types by more than 10-to-1. But don't take our word for it. See for yourself. Call, write or TWX for further information.

Hydromatics, Inc.
Livingston, New Jersey
Telephone: WYman 2-4900
TWX-LIVINGSTON NJ 120

CIRCLE 69 ON READER-SERVICE CARD

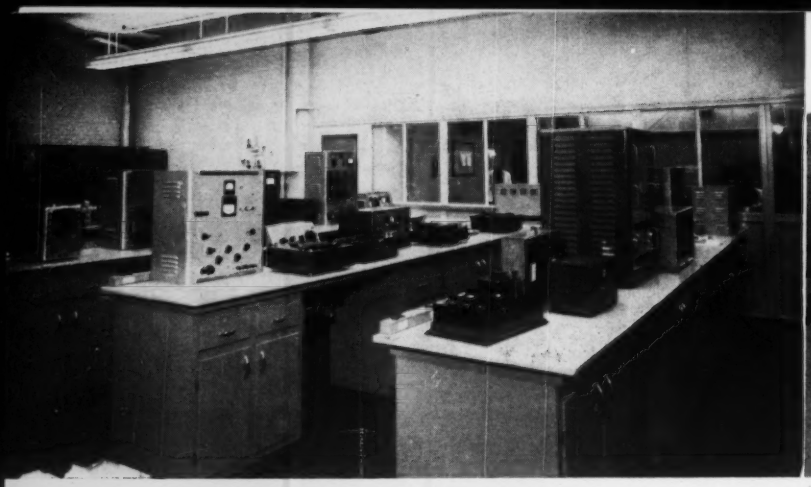


FIG. 1. STANDARDIZING laboratory.

FIG. 2. BANK of standard resistors.

Calibration and Standardization at Weston

DR. R. C. LANGFORD

Daystrom, Incorporated
Weston Instruments Div.

Here is how a leading supplier of precision instruments calibrates and standardizes its own instruments.

NBS has standardized on standard resistors and Weston standard cells as working primary standards for ohms and volts respectively. This practice has been followed throughout industry; our own primary standards also comprise standard resistors and Weston standard cells.

It is important that the working quarters of a standardizing laboratory be good (Fig. 1). A common practice, for example, is to maintain the temperature at 73° + 1½°, with a relative humidity at 50 ±2%. There also is slight pressurizing of the room to help keep out dust particles. Table 1 lists most of the important tests that are required in our own laboratories for our test panels, etc.

Fig. 2 shows a group of standard resistors; the main bank of our primary standards includes 0.00001 ohm up to 100,000 ohms. These resistors are the basic working standards of our company. However, each of these is supplemented by an auxiliary standard of a similar type that could replace the primary standard if some accident should happen to it.

A standard-cell temperature bath maintains three banks of saturated cells at 35°C ±0.01°C. This holds temperature sufficiently constant to hold voltage variations of the cell to within ½ microvolt.

Specific Test Equipment

Fig. 3 shows the Standard Cell Comparator. This equipment checks standard cells rapidly to an accuracy of better than 5 microvolts, and indicates internal resistance of the cell. The comparator's circuitry is shown in Fig. 4.

Four general-purpose pieces of equipment include (1) a d-c calibrator for millivolts, volts, microamps and milliamps, (2) a d-c calibrator for amperes, (3) an a-c calibrator for volts, and (4) an a-c calibrator for amperes.

TABLE 1—TYPICAL TEST REQUIREMENTS

ITEM	RATED ACCURACY	NOMINAL VALUES	NOTES	CALIBRATION ACCURACY
RESISTORS	0.01%	0.0001 Ω TO 10,000 Ω	25°C	0.002% TO 0.005% (0.0001 Ω TO 0.01%)
CURRENT SHUNTS	0.04%	0.00001 Ω TO 20 Ω	1000 AMP TO 0.075 AMP	0.01% TO 0.05%
STANDARD CELLS (UNSATURATED)		1.0183 V TO 1.0198 V		0.01%
RESISTANCE BRIDGES	0.01% TO 0.02%			0.01%
RESISTANCE BOXES	0.01% TO 0.05%			0.01%
KELVIN BRIDGE	0.01% TO 0.02%			0.01%
RATIO BOX	0.01%			0.01%
POTENTIOMETERS	0.01% TO 0.02%			0.01%
VOLT BOXES VOLTAGE DIVIDERS	0.01% TO 0.04%	750 V TO 3 V, 1.5 V	20% TO 100% RATED V	0.01%
FIXED CAPACITORS ADJ. CAP. BOXES	0.1% TO 0.5%	100 μμF TO 1 μF	60 CPS TO 1000 CPS	0.03% TO 0.1%
FIXED INDUCTORS ADJ. IND. BOXES	0.1% TO 0.5%	100 μH TO 10 H	60 CPS TO 1000 CPS	0.03% TO 0.1%
CURRENT TRANSFORMERS	0.3% RATIO 10 MINUTES PHASE ANGLE	0.1 AMP TO 4000 AMP	60 CPS	0.1% RATIO 2 MINUTES PHASE ANGLE
POTENTIAL TRANSFORMERS	0.3% RATIO 10 MINUTES PHASE ANGLE	TO 25,000 V	60 CPS	0.1% RATIO 2 MINUTES PHASE ANGLE
DC AMMETERS	0.1% TO 0.5%	100 μAMP TO 100 AMP		0.05% TO 0.1%
DC VOLTMETERS	0.1% TO 0.5%	0.1 V TO 1000 V		0.05% TO 0.1%
AC AMMETERS AC AND DC AMMETERS	0.1% TO 0.5%	10 MA TO 100 AMP	DC TO 30,000 CPS AC-DC DIFFERENCE	0.05% TO 0.1%
AC VOLTMETERS AC-DC VOLTMETERS	0.1% TO 0.5%	0.1 V TO 1000 V	DC TO 30,000 CPS AC-DC DIFFERENCE	0.05% TO 0.1%
WATTMETERS	0.1% TO 0.5%	0.1 TO 100 AMP 30 TO 1000 V	REVERSED DC AC-DC DIFF. TO 3000 CPS	0.05% TO 0.1%

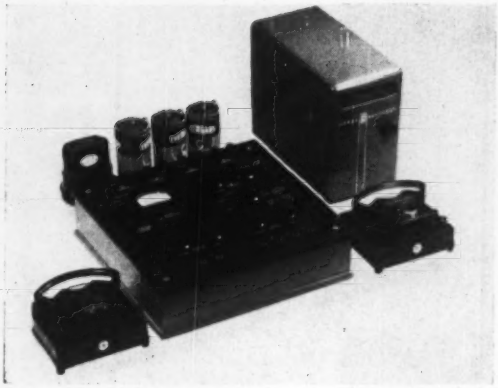


FIG. 3. STANDARD-CELL comparator.

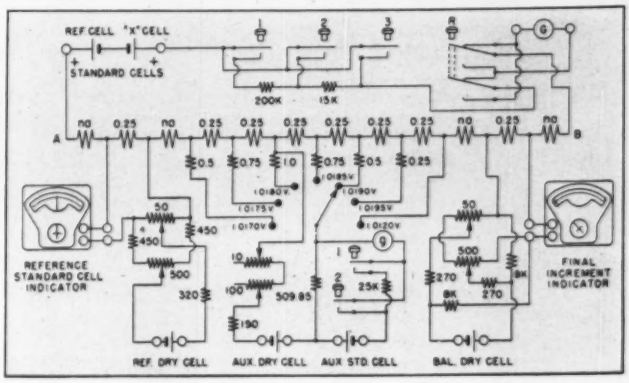


FIG. 4. CIRCUITRY of standard-cell comparator.

D-C Calibrator

Weston Model 64 Calibrator (Fig. 5) is designed specifically for rapid and precise calibration of d-c voltmeter, millivoltmeters, milliammeters, and microammeters.

In Fig. 6 resistors "R" divide the output voltage of the rectifier into fifteen approximately equal parts. Precision resistors are not required in this divider. The resistances of the meters being tested will have a wide range of values, and may not even be known. As the meters being calibrated are in shunt with a variable number of resistors "R" as the output tap is changed, the specific output tap is sampled as to voltage output and this sample compared against the reference standard voltage. The sampling is accomplished by pairs of 0.02% resistors that are matched for ratio and temperature coefficient only. Their absolute values are not critical. Any difference in voltage between this sample and the reference standard becomes the input signal of a very stable and high-gain electronic servo-amplifier whose output adjusts the bias of a series regulator tube in a direction as to reduce the amplifier input signal to essentially zero.

The zero-drift and resolution of the amplifier contribute no more than 0.01% to the possible output error. The sampling resistors can contribute another 0.02%. The standard cell, which is of the unsaturated variety, can drift another 0.005% per year. It may therefore be seen that the rating of 0.05% applied to the output is conservative and valid over extended intervals between standardization checks. Adjustments are provided to standardize the Model 64 against various standard-cell voltages as these cells age.

D-C Calibrator for Amperes

Appearance and regulation of the Model 65 is similar, but precision shunts in the output circuit allow the millivolt drop across them to act as the sample to compare against the voltage reference standard. Any difference is again amplified and then used to regulate the poser supply to exactly the output current required.

A-C Calibrator for Volts, and Amperes

The Weston Model 63 calibrates a-c voltmeters. The Model 62 semi-automatic calibrator provides quick and accurate checking or calibrating of a-c ammeters, from 1 to 50 amperes full-scale.

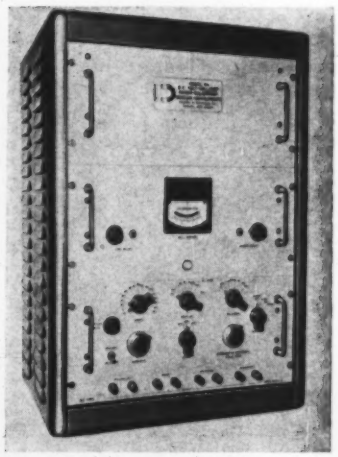


FIG. 5. D-c calibrator.

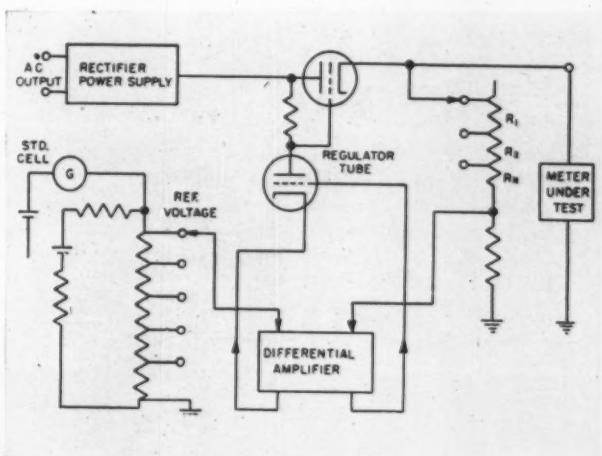
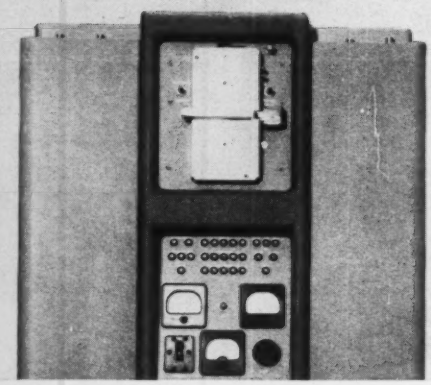


FIG. 6. Circuitry of d-c calibrator.

"Numerical control really pays off using the Bendix G-15 computer"



Joseph Strack

JOSEPH STRACK,
SENIOR TOOL ENGINEER
& PROCESSMAN
THE MARTIN COMPANY,
BALTIMORE DIVISION

The Martin Company uses a Bendix G-15 digital computer for producing punched tapes to operate numerically controlled milling machines. *"Parts are produced in one-fourth the time required by conventional milling,"* Strack writes, *"and comparing price with all other computers used for numerical control, the G-15 stands at the head of the list for economy."*

The G-15 manifests its economy in numerous ways. For example, it is exceptionally versatile. Over 250 are in use covering many facets of engineering, the sciences, business and industry. *"Although the G-15 was installed for a special purpose, its ease of use and various ways of programming have impressed me. It performs our specific task perfectly, and easily solves various mathematical problems."*

The G-15 can be expanded at will. Although the basic G-15 consists of the computer, an alphanumeric typewriter, a high-speed tape reader and tape punch, the user may add accessories to accommodate growing work loads. *"Added storage offered by magnetic tape units enables us to use combinations of routines interchangeably and fully automatically."* Punched card equipment, special high-speed paper tape readers and punches, a digital differential analyzer, a high-speed plotter, and other units are also available.

The G-15 pays off in ease of operation. *"Its simplicity enables the G-15 to be operated by personnel with no computer knowledge or background . . ."* In time savings, *"The G-15 has cut lead time tremendously, both in tooling and part manufacture."*

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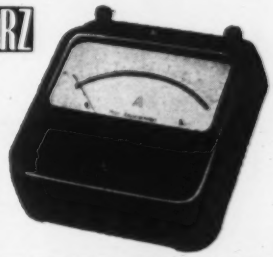
CIRCLE 70 ON READER-SERVICE CARD

Physics Research Laboratories Inc.

"House of Fine Instruments"



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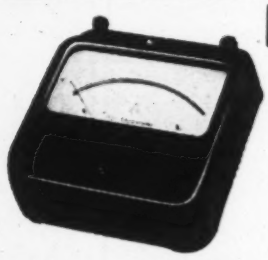

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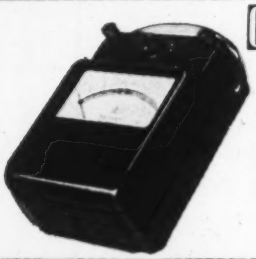

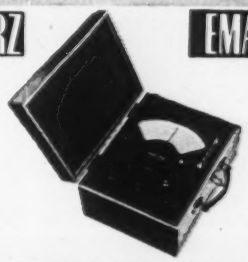

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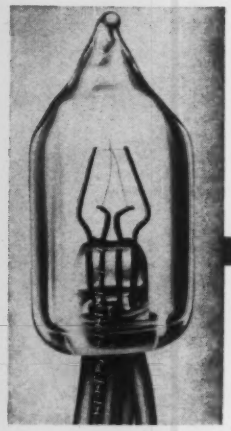

FIG. 1. THERMO-ELEMENT

THERMOCOUPLE CURRENT

Guides for using the versatile ac-dc transfer instrument and for selecting a millivoltmeter and external thermo-element.

THERMO-ELEMENT current indicators have (1) wide frequency range, (2) high sensitivity, and (3) true RMS response, all desirable characteristics for an a-c instrument. In addition, the instrument is a fine ac-dc transfer standard; it can be certified on dc with high-accuracy standards and then used to make a-c measurements up to high frequencies.

Fig. 2 shows the internal construction of a vacuum heater-thermocouple current sensor, more commonly called a *thermo-element*. The current to be measured is introduced by leads 1 and 4 and flows through the heater wire, which is welded to these leads. The current flow through this heater wire (made of high-resistance material) causes the heater to rise in temperature because of the I^2R losses in its resistance. The thermal junction is composed of two dissimilar metals. In insulated elements, this junction is in thermal contact with the heater but electrically insulated from it by a small bead; in contact types one leg of the thermocouple is welded directly to the heater wire. Rated current through the heater will raise the temperature of the junction point to about 300°C; this temperature will produce 10 to 12 millivolts open-circuit EMF in the average vacuum couple.*

The EMF developed in the junction is used to operate a d-c millivoltmeter, which is calibrated in terms of the current through the thermo-element heater wire. Thus alternating current is measured with a mechanism responsive to dc only.

Meter deflection is directly proportional to heater temperature. As temperature is proportional to the *square* of the current through the heater, the meter indication is a true RMS measure of the current.

The vacuum thermo-element is available with rated (maximum) current values of 1 milliampere up to 1 ampere. Fig. 3 shows a typical circuit used for measurements. The circuit shown is being used as a voltmeter; for measuring current, $R = 0$. Calibration is performed by adjusting a series resistance (R_J); an automatic temperature compensation circuit (ATC) can assure constant output over a range of ambient temperatures from 20° to 30°C.

*Guaranteed minimal value is 7 millivolts in Sensitive Research vacuum couples.

Vacuum thermo-elements are, in general, used for current ranges up to approximately 1 ampere. Beyond this range an air couple is used. The construction of air couples in electrically similar to vacuum couples.

Thermo-element Burnout

At rated current through the hot wire, its temperature is about 300°C. If it is overloaded by doubling the current, wire temperature reaches nearly 1200°C because temperature follows a square-law (I^2R). Therefore, it doesn't take much of an overload to burn out a thermo-element.

Millivoltmeter used with External Thermo-element

Frequently an available separate thermo-element and millivoltmeter must be combined—when, for example, a suitable-range self-contained instrument is not available. Also, an external couple and remote instrument is often desirable for high-frequency measurements in order to make the a-c leads short and direct.

The open-circuit millivolt rating for the thermo-element is the open-circuit voltage output of the thermal juncion when the heater is carrying rated current. This is NOT eqivalent to the millivoltmeter range or rating at full-scale deflection because millivoltmeters draw current. Fig. 4 shows a millivoltmeter with internal resistance (R_M) connected to a vacuum thermo-element. The open-circuit emf of the thermo-element (E_J) will not be the voltage (E_2) at the meter because of the IR drops in (1) the internal resistance of the junction (R_J), (2) the series resistance (R_L), and (3) the instrument resistance (R_M).

It can be shown that the most efficient operation is when the resistance of the millivoltmeter (R_M) equals the resistance of the junction (R_J); this provides maximum power transfer.

In thermo-elements for heater currents from 1 milliampere to 1 ampere the junction resistance (R_J) varies from approximately 5 to 15 ohms. Therefore, a 10-ohm 200-microampere 2-millivolt instrument is recommended for use with these thermocouples.

INDICATORS

MICHAEL V. KANE
Sensitive Research Instrument Company

When several millivoltmeters are available and none are exactly matched, a formula will help select the most appropriate meter. The best match of couple and meter can be established in terms of the resistance (R_L) in the junction circuit. R_L consists of the lead resistance (if long leads are used) plus any additional series resistance to give an exact scale deflection on the millivoltmeter. The formula for the relation between R_L and the couple and meter is:

$$R_L = (E_J/E_M)\ (R_M) - (R_M + R_J)$$

where E_M is instrument range in millivolts; E_J is open-circuit millivolt rating of the thermo-element; R_M is instrument resistance, R_J is junction resistance (not heater resistance).

Ordinarily the manufacturer's values for E_J and R_J are nominal values. Therefore, the value of R_L should be determined only roughly by the above formula and most precisely by experimenting with a variable resistance box in the junction circuit with a known standard current of rated value through the heater. The variable resistance box is adjusted to give a full-scale reading for the current. A high value of R_L in the junction circuit makes the measurements less susceptible to extraneous thermal EMF's and to resistance changes in leads and wiring. The higher series resistance also lessens the period of the instrument to some extent, which is desirable in thermocouple instruments because it results in faster measurements.

Sample Meter Selection

Suppose there is a choice between three meters—(1) a 2-mv 10-ohm meter, (2) a 5-mv 25-ohm meter, and (3) a 1-ma 10-ohm meter—for use with a thermo-element having a 7-mv open-circuit output rating and a junction resistance of 10 ohms.

Selection can be made by using formula (1). For meter (1) E_M is 0.002, R_M is 10, E_J is 0.007, R_J is 10. Hence $R_L = 15$ ohms.

For the 5-mv 25-ohm instrument; $R_L = 0$ ohms.

For the 1-ma 10-ohm meter (which is a 10-mv meter); $R_L = -13$ ohms.

Thus the 2-mv 10-ohm instrument has the largest value for R_L, 15 ohms. This is the best of these three meters for use with this thermo-element. The 2-mv instrument should then be put in series with the variable resistance and connected to the thermocouple junction leads. The box should be set to $R_L = 15$ ohms. The calibration is done by passing rated current through the heater of the thermocouple and adjusting the variable resistance box until the millivoltmeter indicates full scale.

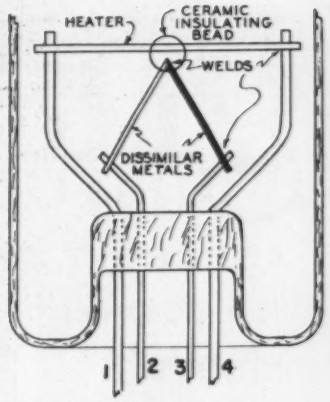

FIG. 2. INSULATED-HEATER thermo-element. Glass bead insulates thermocouple circuit from heater wire electrically, but makes thermal connection between heater wire and thermocouple junction. In a contact-type thermo-element, one leg of the thermocouple is extended beyond the junction and welded directly to the heater wire.

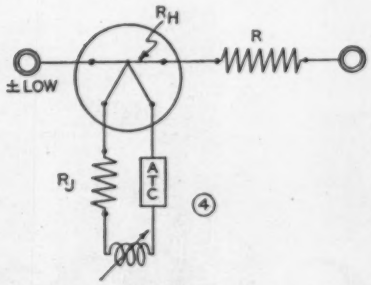

FIG. 3. TYPICAL measuring circuit. When R = 0, instrument measures current. Voltmeter is made by adding resistance R in series with heater.

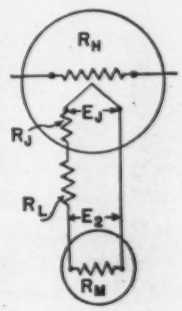

FIG. 4. SELECTION of millivoltmeter for use with an external thermo-element is based on matching internal resistance of couple to that of indicator.

signal action

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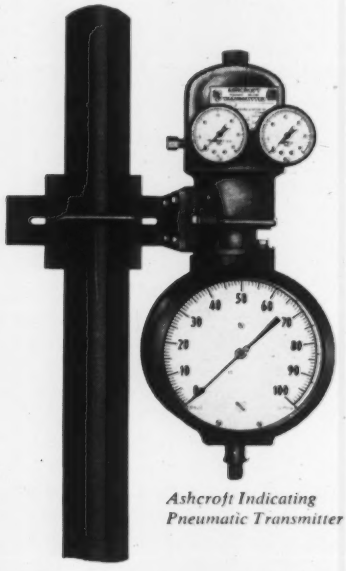

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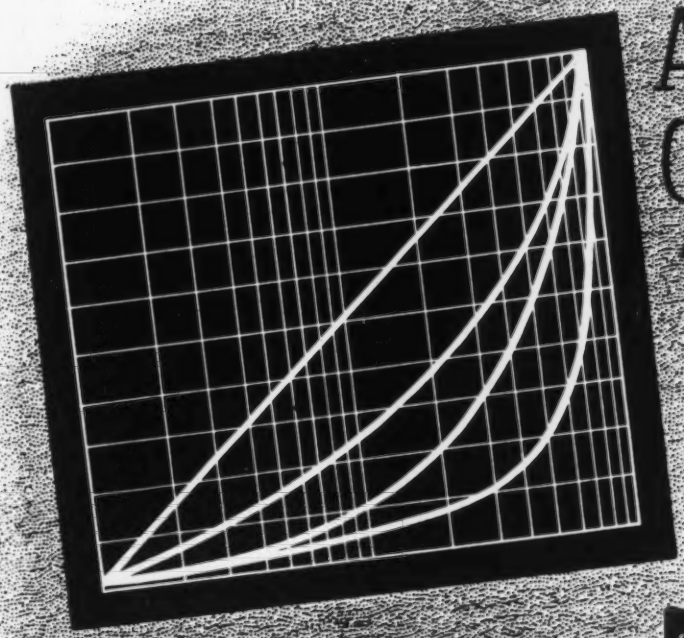

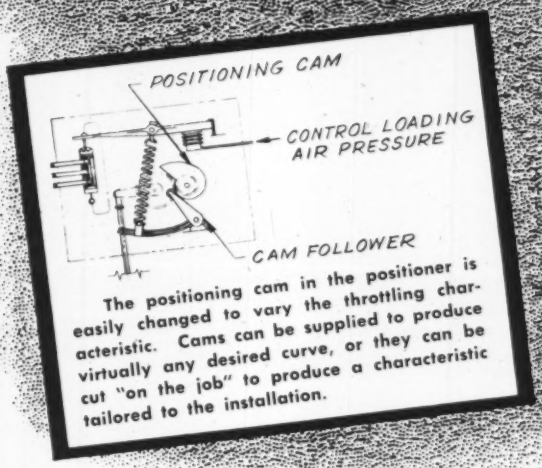

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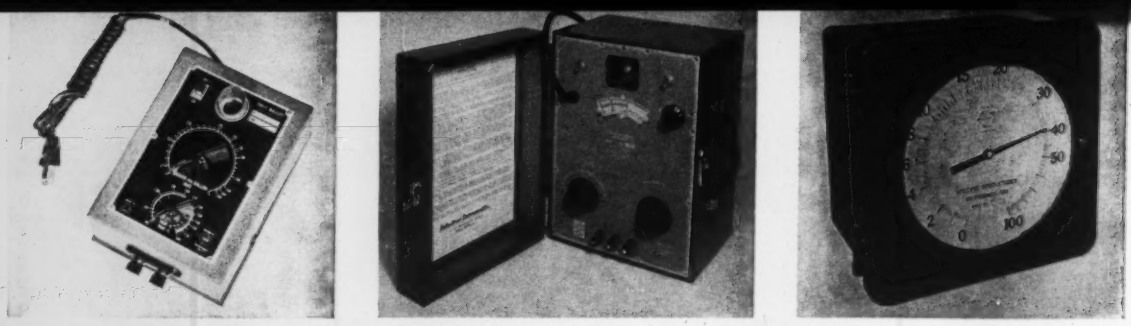

FIG. 1. TYPICAL conductivity instruments include small tuning-eye-balanced models (left), precise bridge units (center), and rugged industrial units (right).

Measuring Solution Conductivity

Conductivity measurements usually involve measurement of resistance by an a-c Wheatstone bridge.

DR. ROBERT ROSENTHAL
Industrial Instruments, Inc.

ELECTROLYTIC or solution conductivity is a measure of the ability of a solution to carry an electric current. The mechanism of electrolytic conduction differs from that of metals. In the latter, current is carried by free electrons; in the former, current is carried by ions only. Electrolytic conductivity is non-specific in that all ions present in a solution contribute to the over-all conductance. Specific conductance is defined as the reciprocal of the resistance (in ohms) of a 1-cm cube of the liquid at a specified temperature.

The unit of specific conductance is the reciprocal ohm, or mho. Since this is a large value of electrolytic conductivity, the practical unit is commonly 1 millionth of a mho, or 1 micromho. High-quality condensed steam and distilled or demineralized water sometimes have specific conductances at room temperature as low as 1 micromho. This would be caused by about ½ ppm of dissolved salt. Absolutely pure water would have a conductance of 0.055 micromho at 25°C.

Conductivity measurements usually involve determination of resistance by an a-c Wheatstone bridge (pH measurements by contrast, require determination of a d-c potential difference, using a potentiometer circuit or a high-impedance vacuum-tube voltmeter).

The Measuring Circuit

The determination of conductivity consists basically in measuring the resistance of a column of solution. Alternating current is almost always used in order to avoid changes in the composition of the solution adjacent to the electrodes due to polarization. Although other measuring systems are in use, the a-c Wheatstone bridge is the most widely used at present and is potentially the most sensitive, stable and accurate. A typical system consists of three elements—an a-c Wheatstone bride circuit, a primary element or conductivity cell, and a null-balance indicator with or without a rebalancing mechanism (Fig. 1).

A system is shown in Fig. 2. D represents an a-c voltage-sensitive device, such as an a-c galvanometer, ear phone, cathode-ray oscilloscope, or electron-ray "tuning-eye" tube. The a-c source can be a low-voltage tap on a 60-cps transformer, an a-c hummer, a vacuum-tube oscillator for higher frequencies, or a dry-cell-operated vibrator.

The voltage varies among instruments (for differing degrees of accuracy and sensitivity) from a few millivolts to 100 volts. The magnitude of the bridge voltage is related not only to the sensitivity of the detector but also to the general characeristics of the electrolytes to be tested. For example, in working with living tissues a low bridge-voltage may be required. The usual industrial measuring and control equipment uses bridge voltages of 1 to 10 volts.

The frequency of the a-c source in commercial units is commonly 60 cps and, sometimes, 1000 cps. Where measurements are to be made on high-resistance electrolytes, such as distilled water or steam condensate, the lower frequency is preferable. For measurements in high-conductivity solutions the higher bridge frequency is sometimes an advantage. Some instruments have both excitation frequencies available (Fig. 1B).

It is often necessary to correct for the temperature coefficient of resistance of the electrolyte. Many electrolytes have a coefficient of the form:

$$R_o / R_t = 1 + at + bt^2$$

An equation of this sort frequently can be set up to hold within 1 to 2% over moderate concentrations and temperature bands. For NaCl the value of a (referred

to 18°C) is 0.241/C°. This agrees with the measured values within relatively small errors from extremely dilute solutions to saturation, and from 0 to 100°C.

R_x in Fig. 2 is the resistance of the electrolyte measured between the two electrodes of the the conductivity cell immersed in the liquid under test. At balance of the Wheatstone bridge $R_x = R_s (B/A)$; this condition is indicated by no current flow through detector D.

The Conductivity Cell

The conductivity cell consists simply of two metal plates or electrodes within an insulating chamber. This arrangement makes the measured resistance independent of both sample volume and proximity to conductive surfaces like tank walls and metal piping. The electrodes usually are coated with a deposit of spongy black platinum which, by increasing the effective surface, reduces the polarizing effect of current between the electrodes.

The measured resistance depends on the size and spacing of the electrodes. For example, large plates located close together will indicate a resistance much lower than small plates that are farther apart. The definition of specific resistance or conductance is based on a 1-cm cube of the liquid. The *cell constant* is a factor used to correct for the size and spacing of electrodes. Larger plates spaced closer together have cell constants less than 1; smaller plates spaced farther apart have cell factors greater than 1. Note: Measured resistance divided by the cell constant gives the specific resistance of the fluid. Conversely, if the liquid has a specific resistance of only 1.35 ohms, and it is desired to balance the bridge at 100 ohms or more, a cell of constant 100 would be selected. With this cell the measured resistance would be 1.35 x 100 or 135 ohms. The cell constant is expressed in units of reciprocal centimeters.

Specification of a conductivity cell for most applications can be made by stating the electrical, chemical, and mechanical service requirements.

Electrical: Experience has shown that the practical limits of measured resistance for reasonable accuracy and sensitivity are between 50 and 100,000 ohms. The first requirement is to select a conductivity cell of such cell constant that the measured resistance of the solution under test will fall within these limits. Constants from 0.01 to 100 reciprocal centimeters are generally available in both industrial and laboratory conductivity cells. Usual values for most applications range between 0.10 and 2.0. A cell of low cell-constant, say 0.1, will have large plates close together and would be used in the measurement of high-resistance (low-conductance) solutions such as distilled water. Moving the plates apart and constricting the electrolyte cross-section increases the cell constant. For highly conductive solutions (for example 20% HCl at 18°C) the measured resistance with a cell of constant 100 would be 135 ohms. By contrast, a cell of constant 1.0 would indicate a measured resistance of only 1.35 ohms in this solution.

Chemical: A conductivity cell must be constructed of materials resistant to chemical action of the liquid.

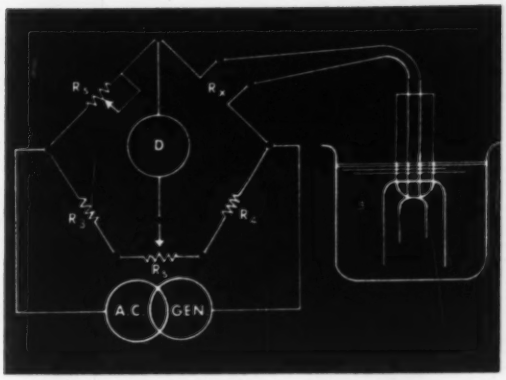

FIG. 2. BASIC conductivity bridge.

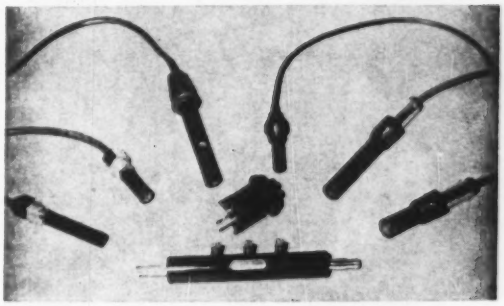

FIG. 3. EPOXY cast cells.

The problem is occasionally complicated by the fact that a-c potentials imposed on the electrode materials can cause the electrode to dissolve slowly.

Mechanical: Usual service limitations of pyrex-glass conductivity cells are around 50 psi and 300°F. Insertion cells have been built for service up to 300 psi at 250°F. A stainless-steel cell is suitable for 500 psi at elevated temperatures.

Epoxy Cast Cells

Conductivity cells cast in epoxy provide high mechanical strength, ruggedness, and resistance to corrosion, high temperature, pressure and thermal shock. Epoxy cast cells are constructed for use as dip cells, screw-in cells and valve-type insertion cells (Fig. 3).

Chief areas of usefulness include measuring (1) pure water, such as distilled water, demineralized water and steam condensates, (2) total dissolved-solids content of boiler-water samples, (3) strong caustic solutions, such as lye peeling where the sodium hydroxide content may rise to 15 or 20% and the temperature close to 200°F, (4) caustic bottle-washing solutions in the soft drink and beer industry, and (5) detergent strength in can and industrial dishwashing equipment.

The glass-smooth finish simplifies cleaning and reduces the tendency to accumulate solids which could change the cell characteristics. Cell constants range from about 0.01 to 100 reciprocal centimeters. Cells of low cell-constant are used for highly resistive liquids, such as pure water, while cells of high cell-constant are used for highly conductive solutions, such as concentrated solutions of acids, salts or alkalies.

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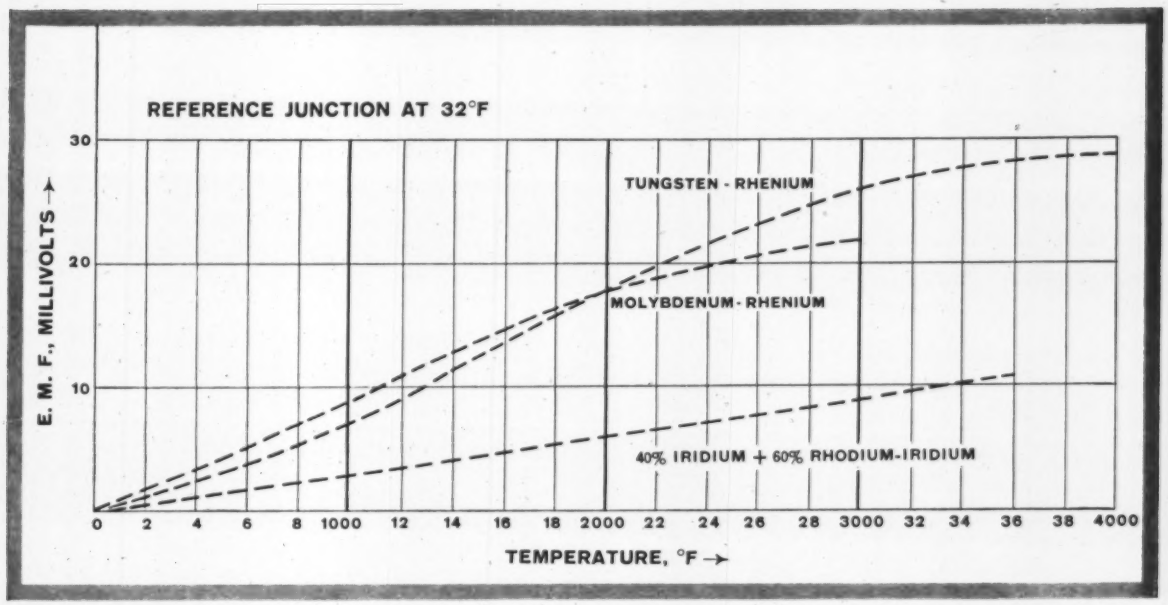
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20
10
TUNGSTEN - RHENIUM
MOLYBDENUM - RHENIUM
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	4000°F	BERYLLIUM OXIDE	1/4	3/8
MOLYBDENUM-RHENIUM	3000°F	ALUMINUM OXIDE	3/16	5/16
40% IRIDIUM+ 60% RHODIUM-IRIDIUM	3200°F	ALUMINUM OXIDE	3/16	5/16
	3600°F	BERYLLIUM OXIDE	1/4	3/8

*HIGH TEMPERATURE ASSEMBLIES WITHOUT PROTECTING TUBE**

Calibration	Maximum Recommended Temperature	Insulator Material	Insulator Dimensions I.D. (in.)	Insulator Dimensions O.D. (in.)
TUNGSTEN-RHENIUM	3200°F	ALUMINUM OXIDE	0.028	0.140
	4000°F	BERYLLIUM OXIDE	0.028	0.130
MOLYBDENUM-RHENIUM	3000°F	ALUMINUM OXIDE	0.028	0.140
40% IRIDIUM+ 60% RHODIUM-IRIDIUM	3200°F	ALUMINUM OXIDE	0.028	0.140
	3600°F	BERYLLIUM OXIDE	0.028	0.130

*Most assemblies available in 5", 11", 17", 20", 23" and 29" immersion lengths.

CIRCLE 74 ON READER-SERVICE CARD

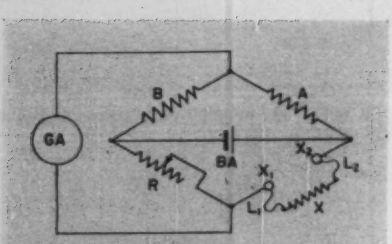

FIG. 1. WHEATSTONE bridge circuit.

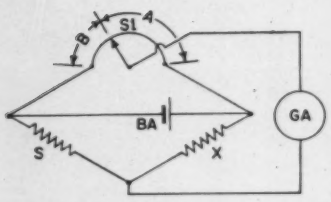

FIG. 2. SINGLE-SLIDEWIRE Wheatstone bridge.

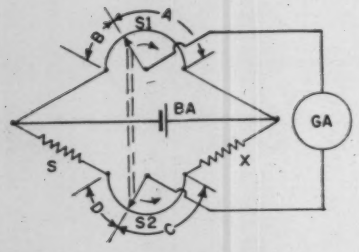

FIG. 3. DOUBLE-SLIDEWIRE Wheatstone bridge.

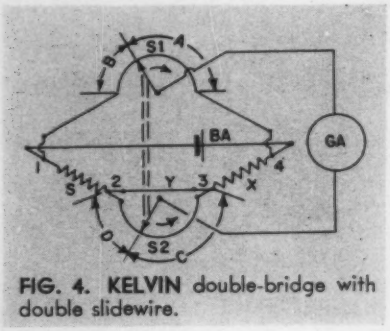

FIG. 4. KELVIN double-bridge with double slidewire.

The Kelvin

A. R. BECHTEL
Gray Instrument Company

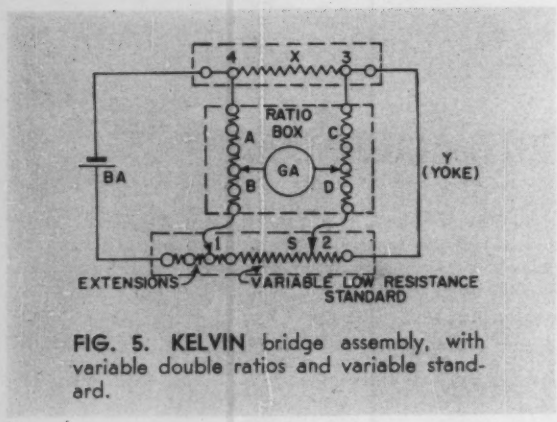

FIG. 5. KELVIN bridge assembly, with variable double ratios and variable standard.

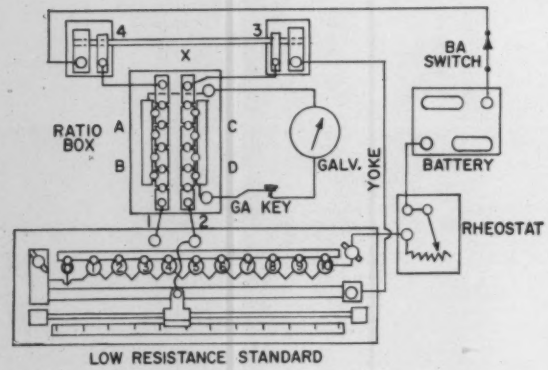

FIG. 6. COMPLETE laboratory Kelvin-bridge set-up.

CREDIT for devising the Kelvin Bridge generally is given to Sir William Thompson (later Lord Kelvin) who first described the circuit in 1862. The Kelvin bridge was designed because the Wheatstone bridge (Fig. 1) generally was found to be inadequate for measuring low resistance.

In order to measure a very low resistance with a Wheatstone Bridge it is necessary to adjust the ratio A to B so that A is much lower than B; then R can be adjusted to enough significant figures to give the desired resolution. However, the result of a low A/B ratio is low sensitivity.

For example, suppose X is 0.001 ohm and we want to measure it to 4 places. The bridge has a 4-decade rheostat in which the lowest decade is 1 ohm, and the highest is 1000 ohms. To read 4 places we must get a ratio such that 1 place on the 1000 dial is equivalent to 0.001 ohm. In other words the ratio A/B would have to be 1/1,000,000. This tremendous unbalance would result in poor sensitivity—the galvanometer movement would be undetectable because only 10^{-6} of the voltage impressed on the bridge would be across the X (and A) arms.

The sensitivity can be increased by increasing the battery voltage. But this again is limited by the current which the ratio arms (the rheostat arm and X) will take without heating. Assuming our bridge has ½-watt resistors, the 1000-ohm resistor in the rheostat arm will take only 0.0225 ampere, which would be put through it by 2.25 volts. Practically the whole voltage

Bridge, and When to Use It

Here is how the Kelvin bridge might have evolved from the Wheatstone bridge, step by step. The choice between the Wheatstone and Kelvin bridge depends on the resistance to be measured and the accuracy desired.

would be across the R and B arms.

If we interchange the battery and galvanometer, and assume A = 0.1 ohm (B = 100,000) we would now be limited by what A will take. At ½ watt a 0.1-ohm resistor will take 0.225 amp, which requires approximately only 0.02 volt. So, while there would be an apparent sensitivity gain by this interchange, the decreased voltage applicable would tend to nullify it.

Evolution of The Kelvin Double Bridge

Wheatstone bridges can have a uniform slidewire instead of the fixed ratio resistors A and B (Fig. 2). A fixed standard resistor (R_s) can be used instead of the rheostat R. The slidewire is graduated to read the ratio A/B. The value of X at balance is:

$$X = (A/B)R_s$$

The slidewire is uniform in resistance, but the ratio scale is logarithmic; in the circuit shown it would read from 0 to infinity, with "1" in the center of the slidewire. (This may have been the first stage of the Kelvin bridge.)

If another uniform slidewire S2, of the same value as S1, is introduced between S and X, and is moved simultaneously with S1, then at balance we still maintain the basic Wheatstone-bridge relation:

$$X = (A/B)R_s$$

$$A/B = (X + C)/(R_s + D)$$

As A = C and B = D:

$$A/B = (X + A)/(R_s + B)$$

$$AR_s + AB = BX + BA$$

$$AR_s = BX$$

$$X = R_s(A/B)$$

Therefore, if S1 and S2 move together the fundamental relation still holds, but sensitivity is improved because the arms of the bridge are not so different in value (as in Fig. 2). Again no current flows through the sliding contacts at balance, and low resistance can be measured without introducing contact problems.

The sensitivity, however, is still low because the resistance of the slidewires is still much more than that of R_s and X when the latter are small fractions of an ohm. However, the amount of current that the slidewires S1 and S2 will stand prevents putting a heavy current through R_s and X to increase sensitivity.

In a circuit such as this the slidewires can be shunted without destroying their proportionality because no current flows through the galvanometer at balance. A low-resistance shunt across S2 will pass much more current through X and R_s without damaging S2 (Fig. 4). This arrangement is the complete Kelvin Double Bridge. The S2 slidewire is shunted by Y so that practically all of the current in that arm passes through Y and only a small portion through S2. As a result, the only limitation on current is the safe current-carrying capacity of the standard R_s and the unknown resistor X.

The shunt Y is generally called the *yoke*, and should be as low in resistance as possible. If it were possible always to have absolute equality between A and C, and B and D, then the current in S2 would be of no consequence. However, in practice there is some difference; hence any appreciable current in S2 accentuates this difference and causes errors in the measurement of X.

Fig. 5 shows a Kelvin Bridge in a form more closely resembling a typical setup. The 4-terminals of resistors R_s and X are apparent. A ratio box replaces the slide-

wires S1 and S2. Note that the low-resistance standard is placed so that as contact 2 (on the bar) is moved, the unused portion of the bar becomes a part of the yoke. As the entire bar is only 0.001 ohm, this has little effect on the reading. The unused extensions (resistors, each of which equals 0.001 ohm) go into the battery circuit where they have no effect on the measurement.

The connections 1, 2, 3 and 4 are generally termed "potential connections." As they carry current at all times during a measurement, it is important that the smaller of the ratios (A/B, and C/D) be kept as high as possible, and that the leads from A to 4, C to 3, D to 2 and B to 1, be as low resistance as practicable. For this reason they are usually large wires and short in length. The yoke Y also should be heavy copper wire and as short as possible.

Fig. 6 shows a typical set-up of low-resistance standard, ratio box, clamps for holding the resistance to be tested, and other accessories.

Portable Kelvin Bridges use the same components —one type has a double slidewire graduated to read ratios, and has a variable standard consisting of resistors which can be plugged in.

Another type has a double dial switch for adjusting the ratios in steps, and a single heavy slidewire for the adjustable standard. Another dial switch extends the standard to 10 times its value in steps of one times the slidewire value (1X). This type is more like the conventional type just described, and has the added advantage that the slidewire scale is uniform and more easily read. Also, two sets of fixed ratios can be adjusted much closer to equality during manufacture than two slidewires.

TABLE 1—ACCURACY OF WHEATSTONE AND KELVIN BRIDGES AT VARIOUS RESISTANCE VALUES

	1%	0.5%	0.1%	0.05%	0.02%
above 10 ohms	W	W	W	W	W*
1 to 10 ohms	W	W	W	K	K**
0.1 to 1 ohm	W	K	K	K	K
under 0.1 ohm	K	K	K	K	K

*For 0.02% accuracy a high-precision bridge, such as the Gray E1000 Anthony-Pattern Wheatstone Bridge would have to be used, and due allowance made for lead resistance.

**It requires a very accurate Kelvin setup (e.g., Gray E-1656 Variable Low Resistance Standard and the E-1655-B Ratio Box) to attain accuracies of 0.02%.

When to Use the Kelvin Bridge

The question of when to use a Kelvin Bridge in preference to a Wheatstone Bridge depends on the size of the resistance to be measured and the accuracy desired.

Contact resistance of the switches in a bridge may be from 0.001 to 0.002 ohm. If you are measuring 1 ohm with a Wheatstone bridge there is an uncertainty of 0.1%, in addition to the actual bridge accuracy. By using large clean contact connections and getting them well tightened down, this uncertainty might be reduced, but it still exists.

If we measure 1 ohm with a Kelvin bridge, the contact uncertainty is put in the ratio arms where it would be in series with possibly 500 ohms, thus its effect would be negligible.

Table 1 shows bridge selection based on accuracy desired—assuming a bridge of sufficient accuracy.

Process Analog-Computer Facility

DR. THEODORE J. WILLIAMS, Monsanto Chemical Company

FOUR main uses to which a chemical-industry analog computer could be placed are:

1. Instruction in computer usage, process dynamics, and control system operation.

2. Investigations of control system response and design.

3. Simulation of control system response and design including rudimentary process dynamics and chemical kinetics.

4. Complete simulation of chemical kinetic systems, process development investigations, and over-all processing system designs with control included.

Each requires a larger and more versatile computer, as shown in Table 1.

No analog computer facility (to date) has ever been big enough to handle all of the problems which were eventually applied to it. Computer facilities have grown in size, flexibility and speed in almost geometrical progression (Fig. 1). Therefore, the first caution one can give to the organization contemplating a computer installation is to be sure that the installation is readily expandable.

Abstracted from ISA paper 56-59.

The nature of chemical problems, particularly those involving chemical kinetics, requires a large number of multiplications and function generations, particularly exponential functions. This accounts for the high proportion of non-linear gear, especially in the larger machines.

Repetitive operation is useful for instruction because the oscilloscope permits extensive display of the dynamics of a process or control system in the shortest possible time. This continuous display demonstrates vividly the effect of changes in system parameters and thus gives the student an intuitive "feel" for process behavior. There are severe limitations in plotting accuracy with such displays. Thus, they may be used only as rough "ball-park" approximations.

The x-y plotter can be a flexible function generator. It is particularly useful for presenting functions such as temperature-variable heat-transfer coefficients, viscosities, and activity coefficients, which cannot be presented readily by standard function generators.

The component distribution of Monsanto's analog computer facility, including its latest expansion, is given in Table 2.

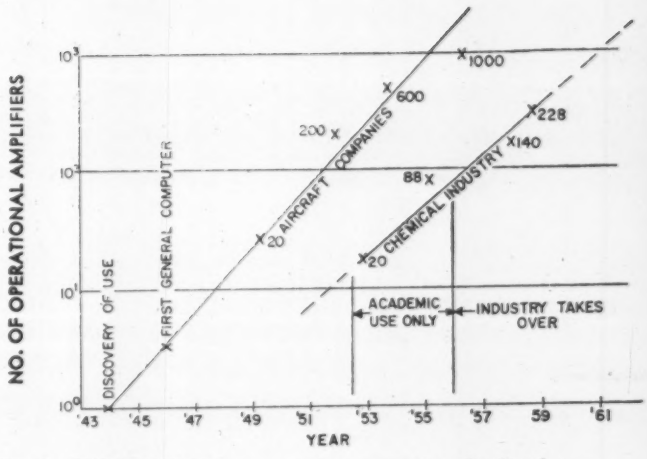

FIG. 1. THE TYPICAL large analog-computing facility has been expanding year by year.

Organization and Personnel

Electrical and mechanical engineers at present have a better background in automatic control theory and the associated mathematics and are recommended almost exclusively for the smaller organizations. As the group delves more and more into the intricacies of the chemical processes themselves, the chemical engineer's knowledge becomes more important; a certain number of electrical engineers are still recommended because of their familiarity with the operation and capability of the computer.

Full-time maintenance personnel are recommended only when the computer becomes large enough to demand such attention (50-100 amplifiers).

Staff for the larger computer continues to increase even though the contemplated problem size also increases. Large-scale computers almost demand multi-shift operation because of the high depreciation charges involved. Thus, the staff recommended is for two-shift operation of the largest machine.

A large computer facility should be operated on a closed-shop basis. However, every effort should be made to obtain the complete cooperation of the person originating each of the problems solved, even to having him observe the actual solution on the computer. Often he will have a feel for the problem which will be invaluable in checking out the computer and evaluating the final results.

TABLE 1—COMPONENTS FOR TYPICAL ANALOG COMPUTER APPLICATIONS IN CHEMICAL INDUSTRY

	Instructional	Control System	Control System With Some Process Dynamics	Complete Simulation
Operational Amplifiers	10-20	15-50	40-100	80-200+
Multiplication Channels	1-2	2-5	10-30	50-100+
Function Generation Channels	1-2	2-6	5-10	25-50+
Operational Relays	1-2	6	12	25-50+
Function Switches	3	6	12	25-50+
Separate Control Consoles	1	1	1-2	2-3+
Plotting Channels x-y	1	1	3	3-4+
Repetitive Operation	Yes	If Desired	If Desired	If Desired
Plotting Channels x-t	2-4	6	12	18

TABLE 2—COMPONENTS IN MONSANTO'S ANALOG COMPUTER FACILITY

Operational Amplifiers	228
Multiplication Channels	
Servo	120
Electronic	9
Total	129
Function Generation Channels	
Diode Function Generator	39
Servo Pot Padder	22
Other	5
Total	66
Operational Relays	48
Function Switches	45
Separate Control Consoles	4
Plotting Channels	
x, y	4
x, t	18
Repetitive Operation	Yes

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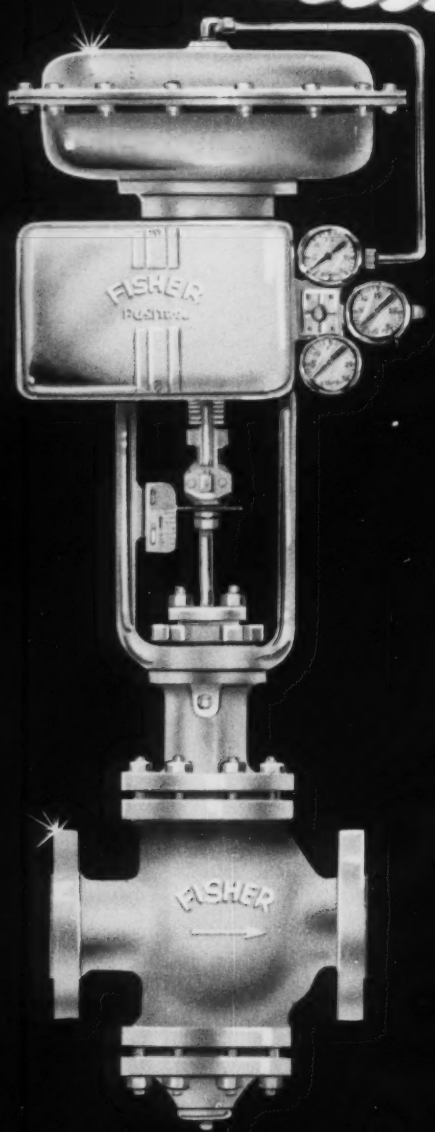

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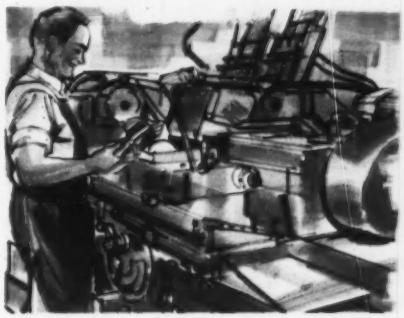

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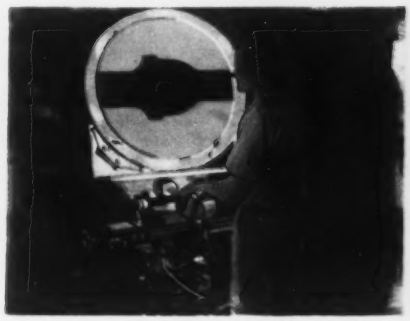

RIGID INSPECTION PROCEDURES

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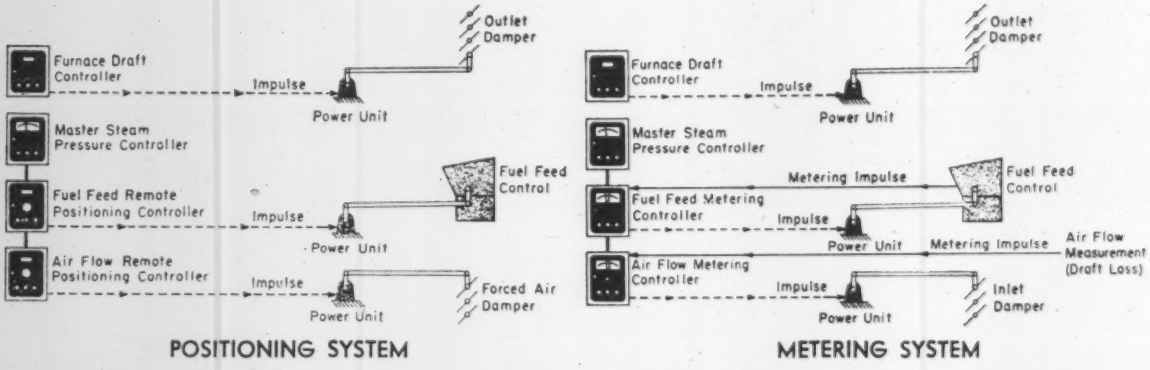
FRED D. MARTON, Instruments Publishing Company

COMBUSTION CONTROL FOR SMALL COAL-FIRED STEAM PLANTS



Small steam-generating plants (output of 3000 to 20,000 lb/hr) outnumber by far their larger counterparts. Their coal consumption lies between 1000 and 8000 tons per year, yet combustion control is often neglected, and a great deal of possible savings goes out through the stack in useless smoke which pollutes the air and creates bad community relations.

Basically there are two methods of control used for such plants—*positioning* and *metering* systems. *Positioning* systems generally control furnace directly while steam pressure positions the air supply dampers and fuel feed control simultaneously, as shown. However, as there is no feedback, the system depends on careful adjustment for its efficiency. Such systems are attended by a host of irregularities such as load on the stoker drive, slippage of drive belts, lost motion in the feeding mechanism, variations in valve pumps, motors, turbines, etc. Thus much manual adjustment and maintenance are required.

Metering systems, however, measure the air flow and fuel flow and feed back the variables. These systems require little attention and are readily calibrated. They are based on metering of the fuel and air for the combustion process and generally use four basic control units—(1) a master pressure controller, (2) an air-flow controller, (3) a fuel-feed metering controller, and (4) a furnace-draft controller.

The master pressure controller has proportional position action. It receives its metering impulse from a connection to the steam header.

The fuel-feeder metering controller is loaded by the master controller and measures the rate of stoker speed by a metering impulse received from the suction of the tachometer blower. It balances this signal against the master-controller loading and sends a control signal to a power unit which (by linkage) adjusts the fuel-feed rheostat that affects the speed of the stoker. Mode of control is proportional position action.

The air-flow controller is similarly adjusted for the required rate of air flow by the master controller. It measures the draft loss across the baffling of the boiler and sends a corrective signal to a power unit which adjusts the inlet damper of the forced-draft fan. Its control action is proportional-speed floating, a form of integral action.

The draft controller measures draft from a connection in the furnace and sends a control signal to a power unit which positions the boiler outlet damper to maintain a constant draft. The mode of control also is proportional-speed floating action.

Equipment used: Master pressure controller, all-electric Model 841:02; Fuel-feed metering controller Model 841:12; Air-flow controller Model 841:31; Draft controller, electric, Model 841:06.

A system similar to the described is installed at American Tobacco Co.'s Richmond, Va. plant.

Source: The Hays Corp., Michigan City, Ind; also Engineering Monograph No. 9.

CIRCLE 75 ON READER-SERVICE CARD

MAGNETIC-AMPLIFIER CONTROL SYSTEM FOR FURNACE USED IN SEED-CRYSTAL PRODUCTION OF SEMICONDUCTORS

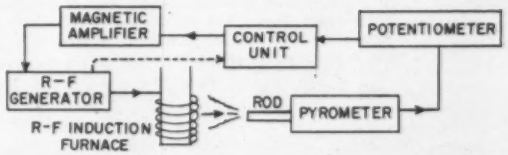
In production of germanium of silicon crystals, two crystal-growing methods usually are used: (1) seed-crystal growing and (2) zone-leveling method. In the former, a rod with a seed crystal at its end is lowered into the melt, then slowly withdrawn. As the metal cools, it forms a single crystalline structure upon the seed. Speed of withdrawal and temperature of the bath determine the diameter of the grown crystal.

This magnetic-amplifier control system controls the temperature of the r-f induction furnace used for melting the germanium or silicon. Silicon requires approximately 1500°C; germanium about 1000°C.

Temperature is sensed by a sapphire-rod radiation pyrometer (Radiamatic 363309). The radiant energy from the object is sighted back through the sapphire rod (much as Lucite conducts light) to a thermopile, whereby an emf proportional to temperature is created. The pyrometer has fast response (63% of full scale in 0.5 sec) and provides a reading of average melt temperature.

The millivolt output of the pyrometer is wired into an "ElectroniK" program-control potentiometer (Model 153) with 12-sec pen speed, 20-mv span (approx. 100°C at 1500°C), suppression continuously adjustable from 0 to 100 mv, and electric-motor set-point indexing.

The control unit (Electr-O-Volt) is a proportional-power output unit which drives a magnetic-amplifier assembly (365235). The latter has 75-v nominal output and is equipped with bias power supply and bias adjusting rheostat. Power output is regulated through a saturable reactor. It is controlled by changing the dc (0-5 ma) from the Electr-O-Volt in accordance with the controlled variable. The Electr-O-Volt unit provides proportional-plus-reset-plus-rate control mode. Corrections for power level or line voltage changes is effected by negative feedback into the control unit when required (dotted line). This system is for an r-f induction furnace.



Equipment used: Primary temperature element is Radiamatic Model 363309; control unit is strip-chart ElectroniK 153 with Electr-O-Volt controller; Magnetic Amplifier is Model 365235; A.T.C. interrupter is Model 4604-10-201C adjusts down-scale drive dial 0 to 100%.

Source: Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Phila., Pa.; also Bulletin M-MM-1-1 "Control Systems for Semi-Conductor Crystal Production" by J. V. Metzger & G. H. Frazier.

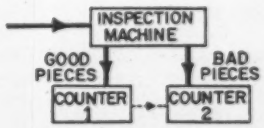
CONTROL OF PERCENTAGE REJECT RATE BY TWO SIMPLE COUNTERS

Standard Impulse Counters can serve as an exact check and control of the percentage of "good" and "bad" units being processed on a rapid production line. This system was installed on a gear checking machine, made by the Cleveland Hobbing Machine Company, that gages the diameter of gears. The control automatically stops the machine upon its ejection of a specified percentage of "bad" gears.

If the "good piece counter" reaches its preset counts before the "bad piece counter" counts out, both counters reset automatically to before-start-position—that is, counter 1 resets itself and counter 2.

If the "bad piece counter" counts out its preset counts before the "good piece counter" counts out, one of the relays supplied in the panel opens a normally closed contact to stop the machine or give an alarm.

In the event of power failure during the operation, both counters will reset to zero position.



Therefore, with this simple installation the customer is enabled to promptly correct the condition resulting in an excessive amount of "bad" or "out of tolerance" pieces upon the first instant of this condition.

Equipment used: 1 Class 2708 Combination Counter Panel (includes 1 Type 2885 ARR-2 Impulse Counter and 1 Type 2885 ARR-4 Impulse Counter); 2 Relays. Also can be provided on baseplate, in enclosure, in explosion-proof housing, etc.

Source: Automatic Timing & Controls, Inc., King of Prussia, Penna., also Bulletin 147.

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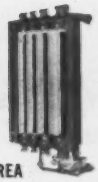

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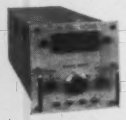

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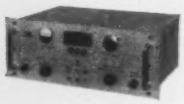

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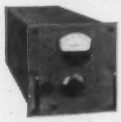

ANALOG FLOW INDICATOR

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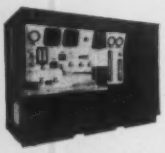

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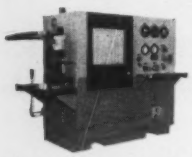

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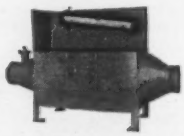

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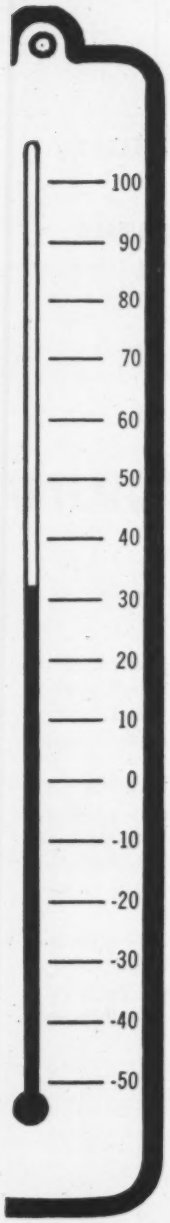

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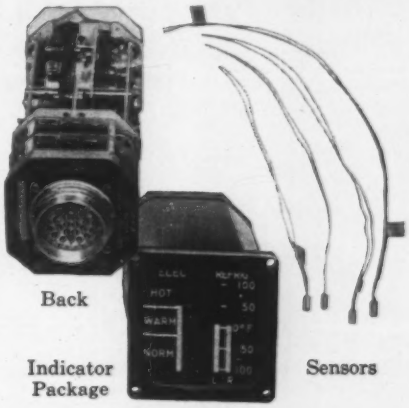

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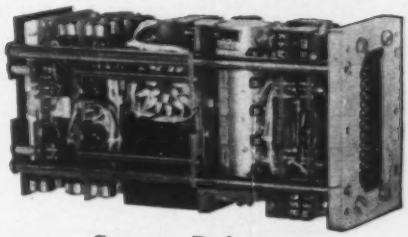

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FIG. 1. TYPICAL 6-dial Kelvin-Varley divider.

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Physics Research Laboratories, Inc.

HANS H. MAROLD
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THE KELVIN-

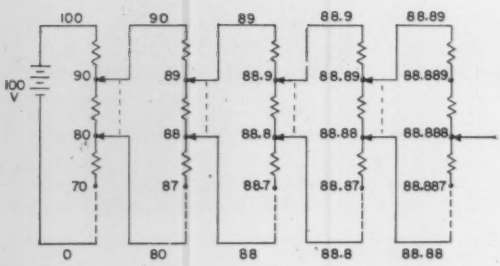
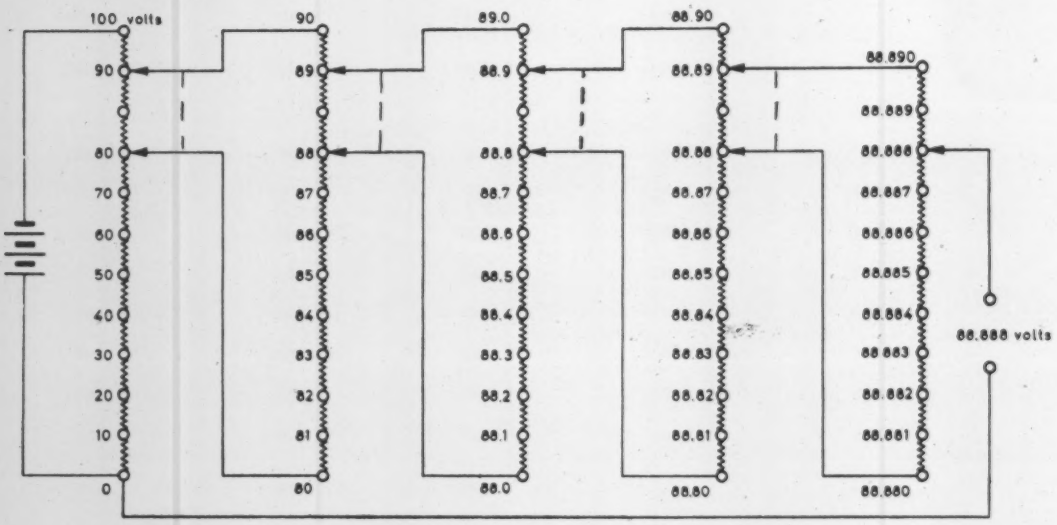


FIG. 2. PRINCIPLE of the K-V divider. Top shows basic principle assuming no shunting effect between successive dividers. Shunting effect is used as below, by having each decade shunt two resistors of the previous decade.

A KELVIN-VARLEY voltage divider uses a cascade arrangement of resistors to subdivide voltages. The most common divisions are 1 to 100,000 to 1 to 1,000,000. Fig. 1 shows 1-to-1,000,000 voltage divider, commonly called a 6-dial divider.

Dial switches are used throughout instead of slidewires because a dial is basically a more positive device. A dial can be reset at the same point and, providing it is of high enough precision, will repeat the reading at this setting indefinitely, whereas it is extremely difficult to make precision slidewires.

The principle is shown in Fig. 2. Let us suppose that each bank of resistors comprises ten equal resistors. Hence each chain divides the voltage across it into ten equal parts. Let us also assume that there is



The Kelvin-Varley voltage divider permits voltages to be divided to an accuracy of 1 part per million.

VARLEY VOLTAGE DIVIDER

no interaction or shunting effect between successive voltage dividers.

If 100 volts are applied across the first divider, as shown, voltages equal to 10, 20 . . . . 80, 90 and 100 volts can be obtained. If we desire a voltage of 88.888 volts, we can apply the 80 and 90 volt potentials across the second divider, the 88 and 89 volt emf's across the third divider, etc., and select the emf of 88.888 volts at the fifth divider, as shown.

In reality, of course, there is interaction between successive dividers. Hence the actual Kelvin-Varley divider is constructed as shown in Fig. 3 and Table 1.

The first decade has eleven 10,000-ohm resistors, but two are shunted by the 20,000-ohm total resistance of the second divider. Hence the total resistance of the first divider is 9 x 10,000 + two 20,000-ohm resistors in parallel (10,000 ohms), for a total of 100,000 ohms.

The second decade has eleven 2000-ohm resistors, but two of these are in parallel with the 4000-ohm total resistance of the third decade. Hence the total resistance of the second decade is 9 x 2000 + two 4000-ohm resistors in parallel (2000 ohms). The total

TABLE 1—VALUE OF DIAL RESISTANCES

Dial No.	Total Resistance in Ohms	Resistance/Step in Ohms	Volts/Step
1	100,000	11 x 10,000	0.1 B
2	20,000	11 x 2,000	0.01 B
3	4,000	11 x 400	0.001 B
4	800	11 x 80	0.0001 B
5	200	11 x 16	0.00001 B
6	200	10 x 3.2	0.000001 B

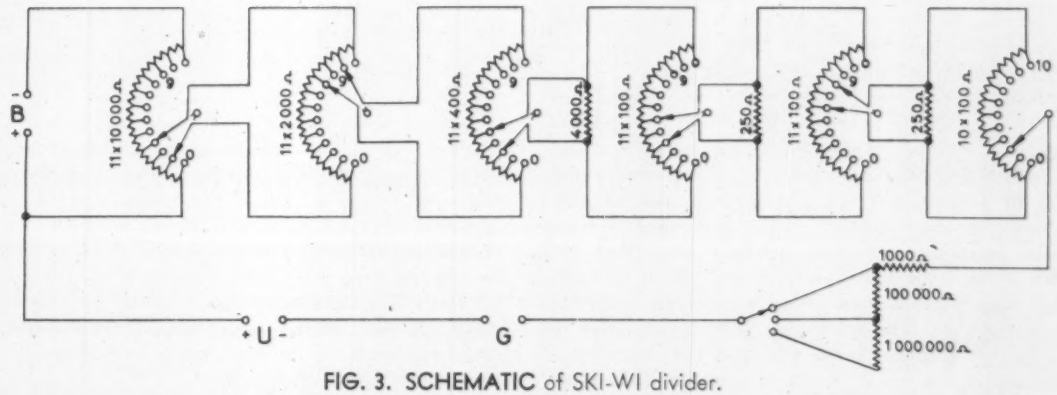


FIG. 3. SCHEMATIC of SKI-WI divider.

TABLE 2—EXACT VALUES OF RESISTANCE FOR FIRST TWO DECADES

DIAL I		DIAL II	
Resistance No.	Resistance Value	Resistance No.	Resistance Value
1	9,999.80 ohms	1	1,999.96 ohms
2	9,999.80 ohms	2	1,999.97 ohms
3	9,999.80 ohms	3	1,999.96 ohms
4	9,999.80 ohms	4	1,999.96 ohms
5	9,999.75 ohms	5	1,999.97 ohms
6	9,999.85 ohms	6	1,999.97 ohms
7	9,999.75 ohms	7	1,999.97 ohms
8	9,999.85 ohms	8	1,999.96 ohms
9	9,999.75 ohms	9	1,999.96 ohms
10	9,999.85 ohms	10	1,999.96 ohms
11	9,999.75 ohms	11	1,999.96 ohms

resistance of this decade is thus 20,000 ohms.

The third decade has eleven 400-ohm resistors, but two of these are in parallel with the 800-ohm total of the fourth decade. Hence, the total resistance of the third decade is 9 x 400 + two 800-ohm resistors in parallel (400 ohms). The total resistance of the third decade is thus 4,000 ohms.

By similar reasoning, the total resistances of the fourth, fifth and sixth decades are 800, 200 and 200 ohms respectively. The results are shown in Table 1.

The first dial divides the supply voltage (B) into tenths. It delivers a span of 1/10 the supply voltage to the second dial for another division by ten. Thus the output from the second dial is any 1/100 of the supply voltage. Each succeeding voltage dial divides a voltage that is 1/10 the voltage across the dial preceding.

The sixth dial has ten steps of one part per million (1 ppm) each of the input voltage, B. Because of certain important practical considerations, such as the zero resistance of the dials, the last three dials are all made up from 100-ohm resistors. In this way, a dial error of 0.0001 ohm is only 0.0001% (1 ppm) of the total at its maximum. Shunt resistors used across the last three dials keep the proper resistance matching so that each position of the last dial is exactly 1 ppm.

The 250 ohms in parallel with the 10 x 100 ohms of the sixth dial gives a total resistance of 200 ohms; the same is true of the fifth dial, and 4,000 ohms in parallel with 10 x 100 ohms of the fourth dial yields 800 ohms total.

Although the interest here is primarily with the use of this type of instrument, the question is often raised concerning the method by which an accuracy of 1 ppm is obtained from a device in which the resistors are not adjusted to within 1 ppm and kept there.

Only the first two decades are of real importance in the computation of errors. Because of the combination of two series resistors in parallel with the entire next dial, the inherent accuracy of subsequent decades may be at least an order of magnitude less than the ultimate accuracy required of the instrument. The relative position of resistors within a given dial can change the error from one part per million to three or four parts per million. Therefore, the two important factors are (1) the accuracy of resistors relative to each other within a given dial, and (2) the relative position of the resistors within a given dial. Table 2 shows typical exact resistances that illustrate requisite resistor accuracy.

Assuming that the total effective resistance of the third dial (10 resistors) is 3,999.93 ohms (which, it can be seen, is the average value for the sum of any two adjacent resistors in the second dial), the total effective resistance of the second dial, to the nearest part in a million, is 19,999.65 ohms. The total resistance of the first dial, to the nearest part in ten million, is 109,997.75. Now, as an example, suppose that the first dial is set on the first position, and suppose that all the other dials are set on zero, then the resistance in the circuit would be.

$$109{,}997.75 - 19{,}999.60 + 9{,}999.80 = 99{,}997.95 \text{ ohms}$$

As the resistance of the first position is 9,999.80, the ratio is

$$9{,}999.80/99{,}997.95 = 0.10000005 \text{ or } 0.1000001.$$

The other positions have either the same, or a smaller, error.

The "zero" resistance effect of the dials is about .1 ppm. As this zero resistance is always positive, the error can be compensated for if the ratio is 0.0999999 instead of 0.1000001. (When +1 ppm is added to 0.0999999, then the ratio becomes exactly 1/10). The zero error thus can be used to bring the total error to within 1 ppm if the ratio is off by —2 ppm because the zero error is always positive.

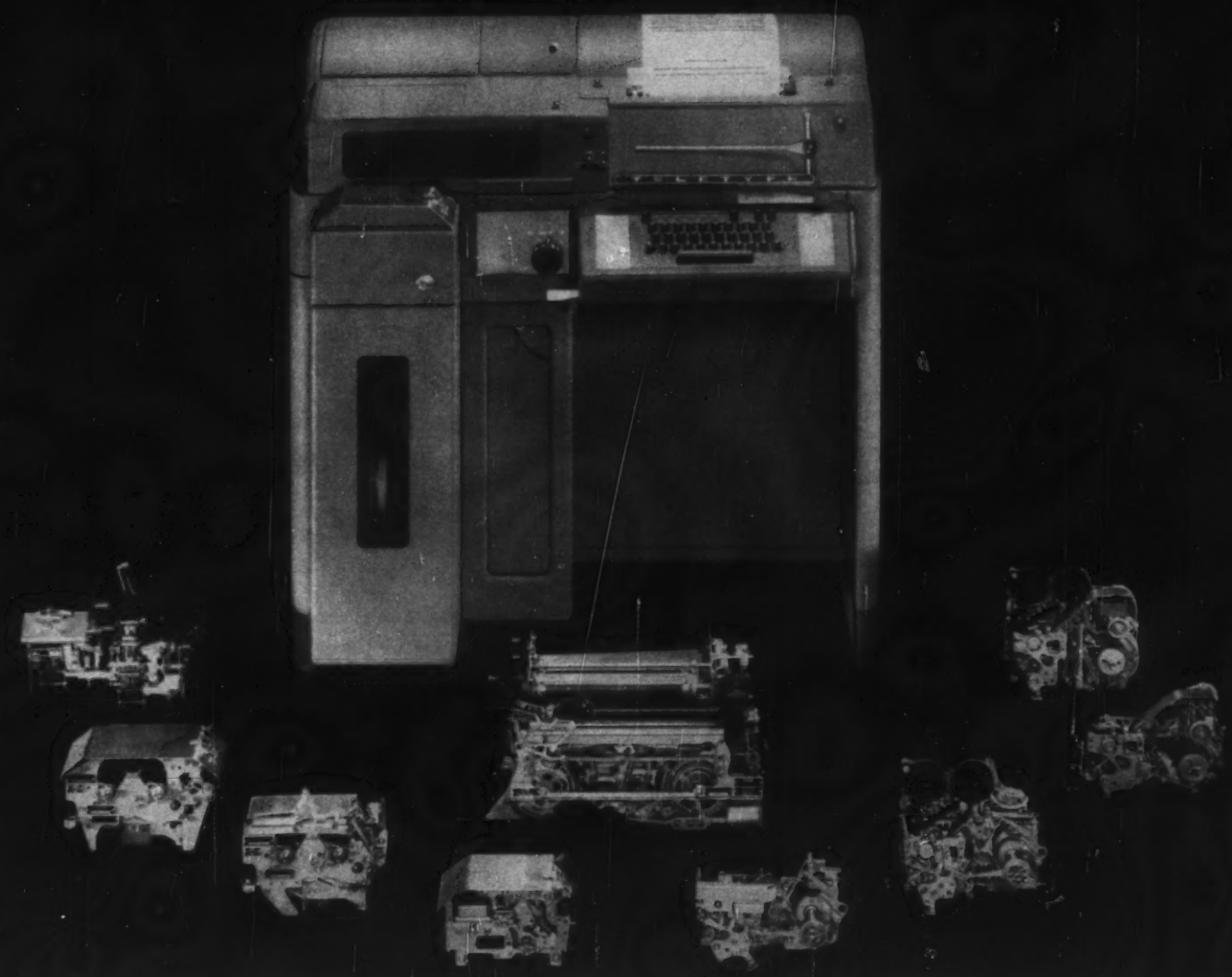
Conclusion

Three requirements must be met for a Kelvin-Varley voltage divider to have an accuracy and resolution of 1 ppm:

1. The total resistance of 100,000 ohms must be held with good, but not extraordinary precision; 9,995.50 divided by 99,955.0 is exactly 1/10, just as much as 10,000/100,000 is exactly 1/10. However, the resistors must have *stability* and remain at the values where they were initially set within close tolerance.
2. The individual resistors must have a small overall spread between the largest and the smallest, although this may certainly be in tens of parts per million.
3. The critical condition is that resistors be matched in pairs so that the spread between two series pairs of adjacent resistors is always small. Thus it must be that the ratio of a series pair in the first dial placed in parallel with the entire second dial will vary from any other such combination in the first dial by no more than 1 ppm.

While the third condition seems almost to contradict the first two conditions, an examination of the resistor values in Table 2 for dial 1 shows they are off from nominal an average of 20 ppm. They could just as well have been off an average of 30 to 40 or 50 ppm. However, if the scatter of the values was such that adjacent pairs could not be formed which would give uniform values, then errors of several parts per million would result.

The first decade is the most critical, and the accuracy and effect of the other resistors diminishes with each dial until, on the last dial, there is no real concern about the accuracy at all.



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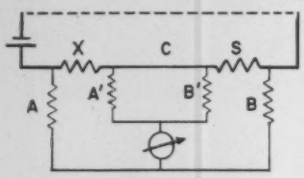

FIG. 1. BASIC CIRCUIT of the Kelvin bridge.

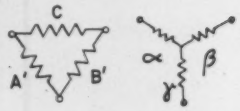

FIG. 2. DELTA-STAR transformation.

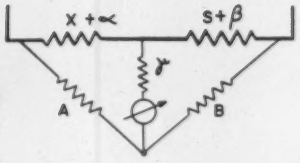

FIG. 3. KELVIN BRIDGE reduced to Wheatstone bridge.

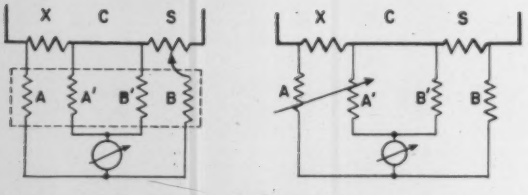

FIG. 4. TWO REALIZATIONS of the Kelvin bridge.

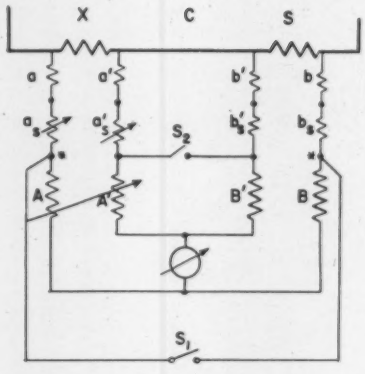

FIG. 5. KELVIN BRIDGE with lead compensation.

Low-Resistance Measurements

LUDWIG F. ROEHMANN
Kaiser Aluminum and Chemical Corporation
Department of Metallurgical Research

A special Kelvin Bridge can provide lead compensation. Such compensation is needed to measure resistance of a bus-bar carrying 3,000 amperes.

A WHEATSTONE BRIDGE measures an unknown resistance X plus the two contact resistances in series with it. Suppose the unknown resistance has a value of 1 ohm, and each contact resistance has one milliohm (1/1000 ohm). The measurement is then in error by 0.2%, which may, or may not, be tolerable. If the unknown resistance is 1/100 ohm the error increases to 20%, which, as a rule, is not tolerable.

For this reason it is good practice to limit resistance measurements with a Wheatstone bridge to values of 1 ohm and more. For lower resistances the Kelvin bridge is called for.

Fig. 1 shows the basic Kelvin bridge. X is the unknown resistance, S the known standard resistance, C is the "yoke" connecting X and S, and A, A′, B′, B are the ratio arms. The contact resistances, while still present, are made innocuous because they are now in series with the ratio-arm resistances which are at least ten ohms and, usually, hundreds and thousands of ohms.

The equilibrium condition of the Kelvin bridge can be derived by reducing the Kelvin to a Wheatstone bridge. This is done by transforming the triangle A′CB′ into an equivalent star (wye) $\alpha\beta\gamma$ (Fig. 2). According to circuit theory the star resistances are the "product of adjacent sides over the perimeter." Therefore

$$\alpha = \frac{A'C}{A' + B' + C} \qquad \beta = \frac{B'C}{A' + B' + C}$$

The transformation reduces the Kelvin bridge (Fig. 1) to the Wheatstone bridge (Fig. 3). As the resistance γ is in series with the galvanometer, it does not influence the equilibrium.

Equilibrium condition of the Wheatstone bridge is "equality of the cross-products":

$$(X + \alpha)B = (S + \beta)A$$

hence

$$X = (A/B)(S + \beta) - \alpha$$

which resolves to

$$X = (A/B)S + K$$

with

$$K = \frac{(A/B)B'C - A'C}{A' + B' + C}$$

As in the Wheatstone bridge, the unknown resistance equals (A/B)S provided K equals zero. This is approximately true if C, the yoke resistance, is negligibly small; it is accurately true if

$$A/B = A'/B'$$

Note: If $A/B = A'/B'$, then reading is independent of C, which may be of same order of magnitude as, or even larger than, X or S.

Two practical embodiments of the basic circuit of Fig. 1 are in existence. They are shown in Figs. 4A and 4B. Both circuits satisfy the condition $A/B = A'/B'$. Fig. 4A is the better known circuit; the standard arm, S is variable (a heavy manganin slide wire). The resistances A, A′, B′, B are fixed plug-type resistors installed in a "ratio box" and have values of multiples of ten. For instance, for $A = 100$, $A' = 100$, $B' = 1000$, $B = 1000$, then X will be 1/10 of S.

In the circuit of Fig. 4B, X is a fixed four-terminal standard resistor, the ratio arms A and A′ are jointly variable resistors (coupled decades), and the ratio arms B′ and B are plug-type resistors, to be set at the same ohm values.

In bridges of the type 4A the current through X is limited by the rating of the standard resistor S. As a rule, this is 50 amperes. For many applications, this limitation is of no consequence, and bridges of this type are used widely.

High-Current Applications

However, there are applications where the current must not be limited to a low value. For example, one may wish to determine the performance of a bolted or welded joint in a high-current bus, or of a compression connector in a heavy power cable, under the effect of load cycles. If only a bridge of type 4A is available one measures the cold resistance in the "current-off" period; or else one can measure the resistance immediately after shutdown as a function of time, plot the logarithm of resistance vs time on a semi-log paper and, by extrapolation back to time zero, obtain the hot resistance prior to shut-down. In no way can one measure resistance during the heat-up and during the "current-on" period.

For such measurements, the arrangement of Fig. 4B is called for. The standard resistor S will have a value of the same order of magnitude as the unknown X: 1/100, 1/1000 or 1/10,000 ohm and, at the same time, adequate current rating for continuous loading—up to several thousand amperes for the smallest ohm value.

Lead-Resistance Compensation

For highest precision, an additional refinement is required. Note that the yoke resistance C, in very high-current measurements, will not be negligible. If the unknown resistance is a joint in a heavy bus or cable, it cannot be connected to the Standard without an intervening length of conductor, and the resistance of this "yoke" may be in the same order as, or even greater than, X and S. Furthermore, the bridge may be physically removed from the test object: the latter may be in a temperature-controlled chamber, the former in the main laboratory. Hence there will now be, between the precision ratio-arm resistors (A, A′, B′, B) and the contact resistances at X and S (which are still negligibly small), *lead resistances* a, a′, b′, b in the order of tenth of an ohm. If these introduce errors, "lead compensation" is called for.

FIG. 6. HIGH-CURRENT Wolff Kelvin bridge with lead compensation.

Basically, variable small series resistances (a_s, a'_s, b'_s, b_s) are inserted between the ratio arm resistors and the leads and adjusted in such a way that

$$\frac{a + a_s}{b + b_s} = \frac{a' + a'_s}{b' + b'_s} = \frac{A}{B} = \frac{A'}{B'}$$

If this condition is fullfilled—that is, if the leads are balanced—$X = (A/B)S$ even if the yoke resistance C is not negligible.

Various lead-balancing circuits have been described in the literature. Several have the disadvantage that lead balancing requires interruption of the main circuit. The arrangement shown in Fig. 5 avoids this shortcoming. With the switches S_1 and S_2 open, the main bridge is first balanced by adjusting A A′ as shown in Fig. 4B. Then S_1 is closed. This puts the points marked with an asterisk at the same potential. As a consequence, A and B in parallel are now in series with the galvanometer, like the resistance γ in Fig. 3. Therefore, they have no effect on the equilibrium. Resistance a_s is varied until

$$\frac{a + a_s}{b + b_s} = \frac{A'}{B'}$$

This balance is made with full current but with reduced galvanometer sensitivity. Similarly, after opening S_1, S_2 is closed and a'_s is varied until

$$\frac{a' + a'_s}{b' + b'_s} = \frac{A}{B},$$

again with reduced galvanometer sensitivity. Finally, with both switches open and full sensitivity restored, the main bridge is balanced once more.

Fig. 6 shows a precision Kelvin bridge built by O. Wolff embodying the circuit of Fig. 5. At the bottom are the five coupled decades of the variable ratio arms (A, A′). The fixed ratio arms (B′, B) each of 50, 100, 200, 400 ohms, are at the right. The galvanometer sensitivity controls are at the top center, the switches S_1 and S_2, in the form of plugs, are in the center; the lead-balancing resistors (a_s, a'_s, b'_s, b_s) are at the top left and right. The bridge has given excellent service since its installation in our Conductor Laboratory in 1953.

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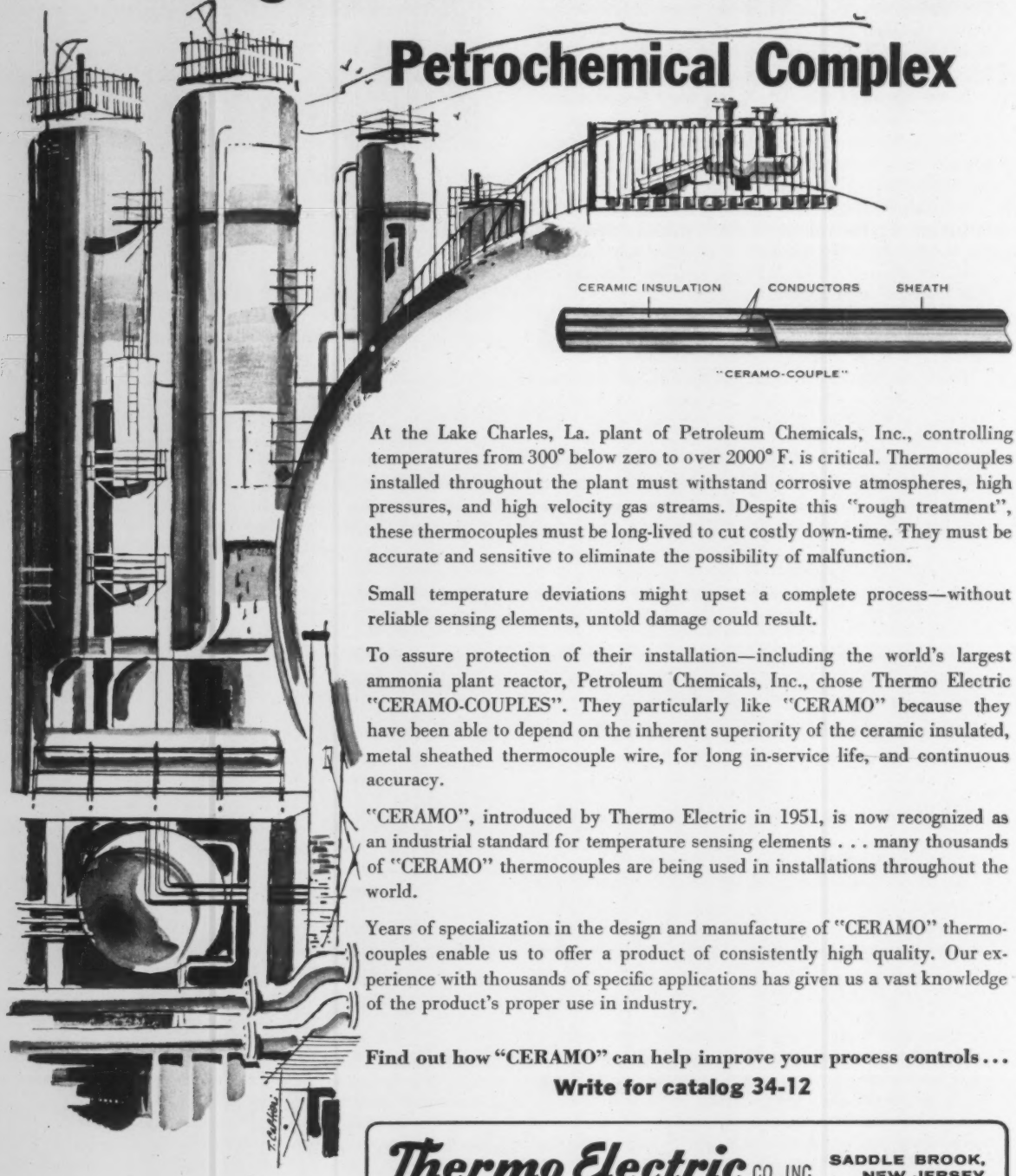

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CIRCLE 80 ON READER-SERVICE CARD

The Asymmetric Bridge

ALVIN B. KAUFMAN, Litton Industries

An asymmetric half-bridge can have better linearity, sensitivity and power output than a symmetric full-bridge. Principles discussed can apply to resistance or impedance bridges.

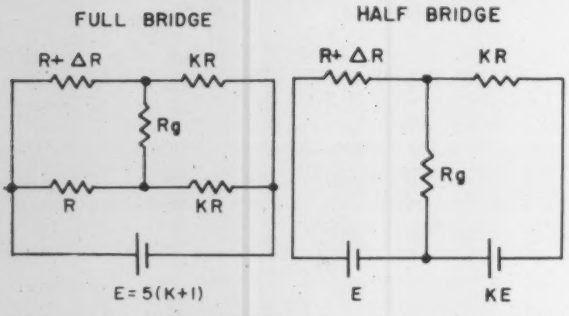

FIG. 1. FULL BRIDGE (left) is a Wheatstone bridge. Half bridge (right) uses two power sources. R_g is load, or resistance of galvanometer. Bridges are symmetric when $K = 1$, asymmetric when $K \neq 1$.

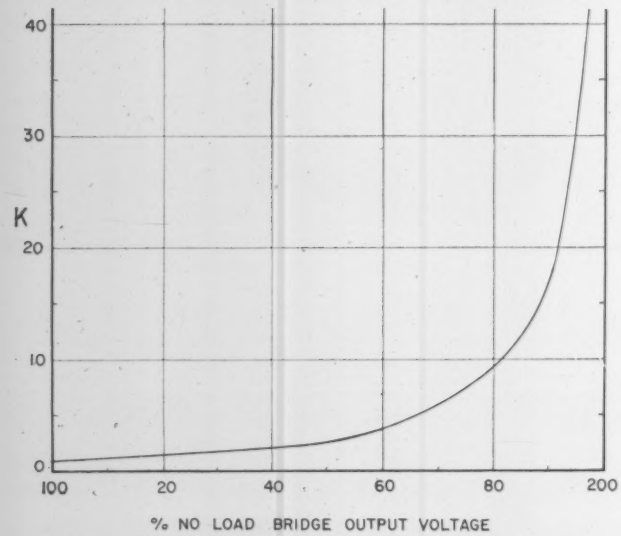

FIG. 2. AS K varies from 1 to 50 the output voltage of full or half bridge changes by a factor of nearly 2.

ASYMMETRIC HALF BRIDGES offer improved linearity, increased sensitivity, and greater output power than is obtainable with the symmetric full bridge. They can improve sensitivity or power gains by 400% without increasing the I^2R dissipation in the active element. One reason why these advantages are not widely recognized is that asymmetric bridges discussed in the literature[1] use one power source, as in the Wheatstone bridge, whereas the benefits of the asymmetric bridge are realized best by use of two sources in a half-bridge arrangement.

In designing a bridge to measure the change in resistance of a sensor, such as a strain gage or resistance thermometer, the output signal depends on the power level allowable in the sensor element. Fig. 1 shows a conventional Wheatstone or full bridge (left) and a half bridge (right). The sensor has resistance R, which can change by ΔR; R_g represents the load, or resistance of the detector element.

Note that the voltage levels in the full bridge and half bridge are the same. For maximum sensitivity, it is desired that the sensor be energized with its maximum allowable voltage. Let us assume that this voltage is 5 volts. If K is 10, then the supply for the full bridge can be 55 volts without exceeding the sensor limitations. The bridge arms divide this supply so that 5 volts appear across the sensor, and 50 volts across the KR arms.

The half bridge has the same voltages by using one 5-volt source and one 50-volt source.

Fig. 2 shows the voltage change that appears across R_g when the sensor changes by one percent, if R_g is infinite (no load). As K varies from 1 to 50, the bridge output voltage changes by a factor of nearly 2. Both the full bridge and the half bridge have the same no-load voltage signal.

However, if R_g is not infinite (a loaded bridge), power output becomes a factor. Here the half bridge is significantly better (Fig. 3). The half bridge offers lower output impedance and thus greater output power can be secured.

Excitation voltage for the half bridge can be supplied by a closely regulated magnetic-amplifier-type power supply which furnishes two separate d-c outputs. Thus the power supply is within the bridge, one output in each leg. No cross-modulation results because the power supply is effectively a zero-impedance element.

The half bridge has other important advantages—wiring is reduced, power-consuming dummy legs are eliminated and, most important, the center tap of the

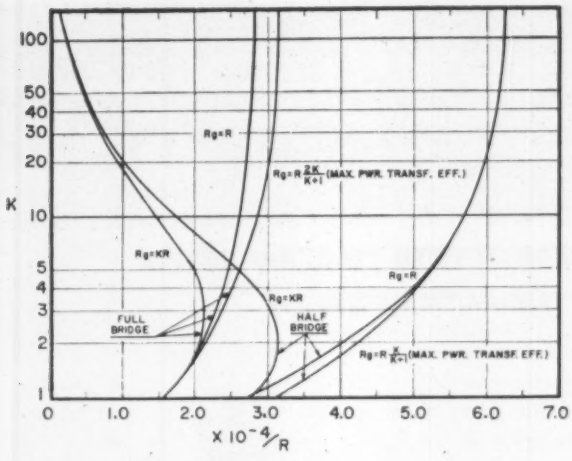

FIG. 3. POWER OUTPUT of full bridge and half bridge for 5-volt drop across active arm and 1% change in its resistance, as K varies from 1 to 100. The half bridge can have twice the power output.

potential source may be grounded. This allows multiple bridges to operate from one common power supply without serious interaction. This is especially important to telemetry applications where all outputs have to work against ground.[2] With full bridges, commutation is required to secure the same operational parameter.

The asymmetric bridge (full or half) is capable of increased linearity because the current flow through the active or sensor arm is (at high asymmetric ratios) effectively independent of its resistance. In the symmetric bridge this is not so. Fig. 4 shows the improvement in linearity as K is increased from 1 to 20 in a half bridge.

Fig. 3 shows that the loaded asymmetric half-bridge (K = 20) can produce *four times* the power output of a symmetric full bridge (K = 1); one factor of two results from use of the half bridge rather than the full bridge, the other factor of two results from use of the asymmetric bridge rather than the symmetric.

The limitation of the asymmetric bridge is expressed in terms of variation of active-arm resistance, desired linearity, and reasonable value of asymmetric-leg potential. Power dissipation in the asymmetric-leg and power-supply wattage requirements also must be considered.

Figs. 2 and 3 are for a 1% change in active element. Greater excursion of resistance would affect the linearity. The linearity of the asymmetric bridge, however, remains superior for all conditions of loading and with narrow or wide excursion of the active-arm resistance.

Linearity is not a significant problem where null reading is employed. There are, however, many applications of the bridge where nulling, manually or automatically, is not desired. Such an application can be the measurement of temperature or strain; an out-of-balance bridge voltage is required and this can be recorded by an oscillograph,[3] transmitted via telemetry, or supplied to direct-reading meters.

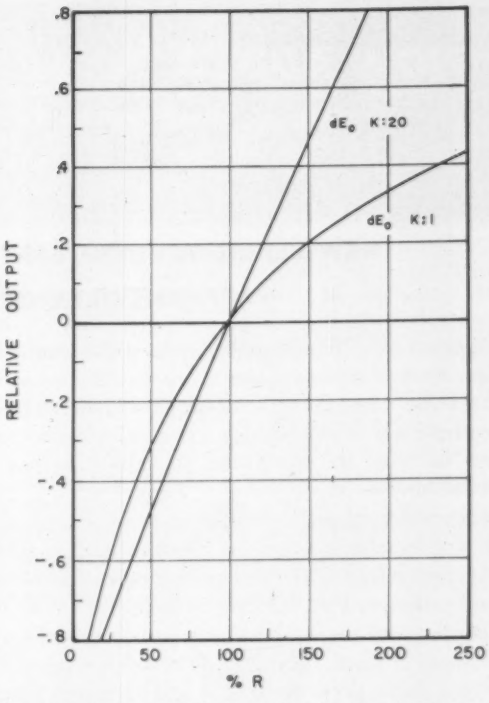

FIG. 4. LINEARITY OF half bridge (no load) is improved as K is increased from 1 to 20.

Bridge linearity under load can be improved if the bridge is so designed that the active sensor decreases in resistance rather than increases (Fig. 3).

The power requirements of the asymmetric bridge and the power dissipated in the dummy arm usually establishes the K factor value selected for the bridge. A factor K of 20 approximates the knee of the power-voltage gain curve (Fig. 2). This, or a higher value, is desirable but not always practical. If the active leg potential is 30 volts, the KE potential would be 600 volts. If 1 watt were dissipated in the active leg, 20 watts would be dissipated in the KR dummy leg. Fortunately, at lower K values significant gain in performance can be secured; for example, K=2 provides a gain of 45%, K = 5 a gain of 65%. Additionally, in many cases a high active-leg potential is not required; one volt is used for many temperature bridges to limit dissipation in the temperature sensor. The sensor may dissipate 10 milliwatts, the KR dummy 200 mw at K = 20, and KE would be 20 volts. These figures are reasonable, and the higher ratio can be used. The higher the allowable excursion of R, the higher the K factor should be if linearity and gain performance are to be secured.

References

1. Huss, P., "Important Factors in the Design of Bridge Networks Used in Instrumentation," ISA Paper 52-10-2.
2. Kaufman, A., "Telemetered Temperatures," *Instruments and Automation*, August, 1955.
3. Kaufman, A., "Oscillographic Strain Gage Recording," *Radio Electronic Engineer*, September 1950.
4. Unbalanced Bridge Characteristics (Abstract), *Electronic Design*, November, 1955.

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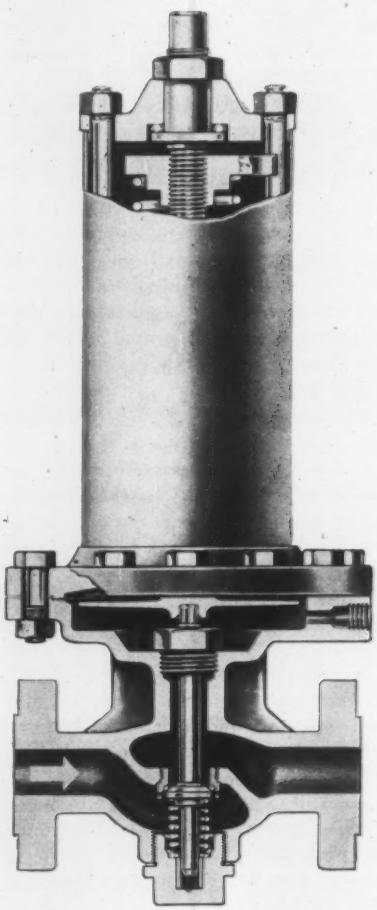
It can handle low-reduced pressures and is used in process lines, steam heat reducing stations and for make-up steam supply to heaters, gland sealing system and process equipment. You benefit from added reliability, plus the accuracy of a pilot operated valve and the rugged simplicity of direct operation. It means less shut-down time for maintenance, surer pressure control and increased plant efficiency.



SPECIFICATIONS

Sizes, Body Materials and End Connection:
½—2", cast iron, and bronze, screwed, 150 and 300 lb. bronze, flanged.
1—2" 125 and 250 lb. cast iron, flanged bodies.

Three Spring Ranges: *2-10 psi; 5-20 psi; 15-35 psi.*

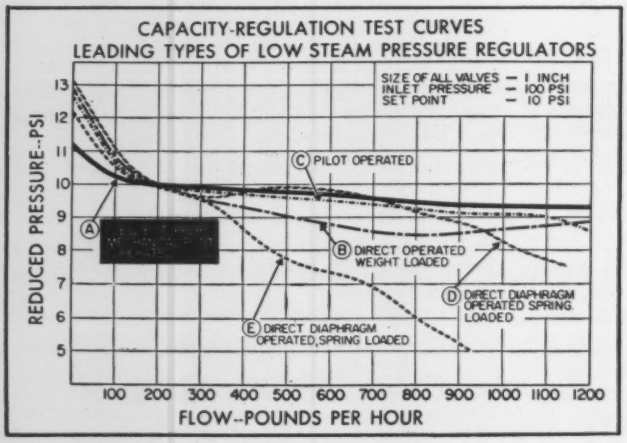
Long-travel metal diaphragm: *2 ply, phosphor bronze, Spiro-flex.®*

Main Valve: *Hardened 440C stainless steel.*

Seat Ring: *Stellited stainless steel.*

Stem Guides: *Gun metal bronze (top and bottom guided).*

Main Valve Spring: *Inconel.*



For sizing and capacity data, contact your Leslie Engineer or write for Bulletin 582.

LC-8

CIRCLE 81 ON READER-SERVICE CARD

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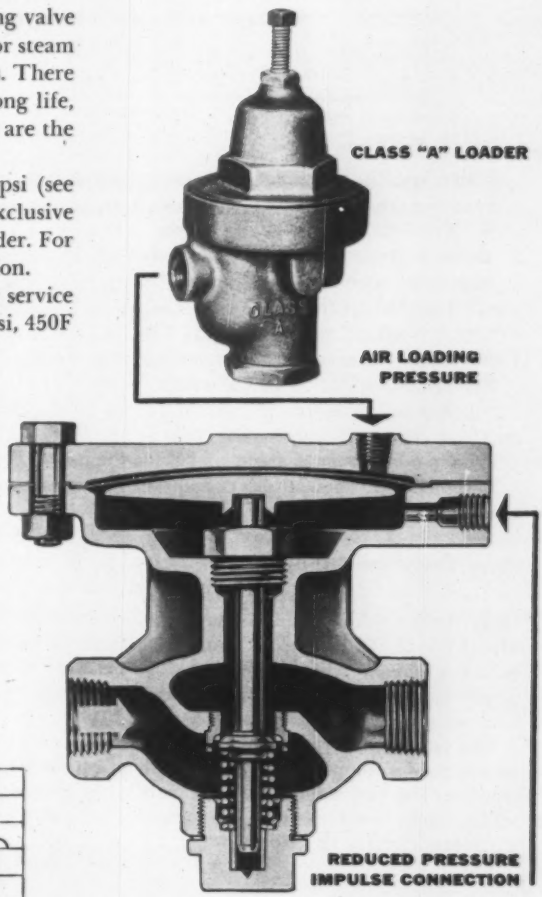
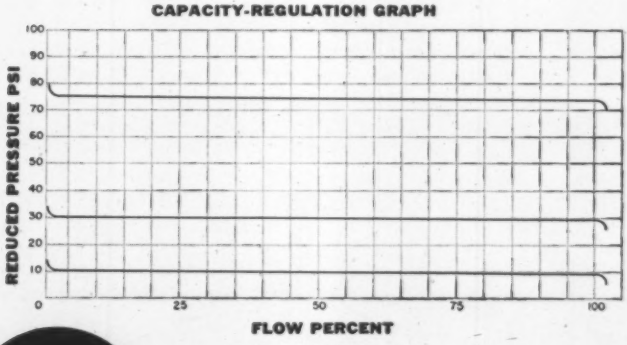
Especially desirable for poor steam conditions and standby service requirements, the GPK is suitable for steam service up to 250 psi, 450F and is available in ½" to 4" sizes.



SPECIFICATIONS

Sizes: ½ to 2", cast iron or bronze, screwed ends. 2½, 3 and 4", cast iron, 125 or 250 lb. flanged.
Main Valve: Hardened 440C Stainless Steel.
Seat Ring: Stellited Stainless Steel.
Stem Guides: Gun Metal Bronze (top and bottom guided).
Main Valve Spring: Inconel.
Inlet Pressure Range: 0-250 psi, 450°F.
Reduced Pressure Range: 0-85 psi with Class A loader, up to 249 ½ psi with any suitable high pressure loader.
Minimum Pressure Drop across Valve: ½ psi.
Available with manual opening device in sizes ½—1¼".

CAPACITY-REGULATION GRAPH



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CIRCLE 81 ON READER-SERVICE CARD

Current and Voltage Standard Supplies

Additions to our previous survey (Sept., 1959) of voltage and current supplies with standard accuracies.

Control Methods Co.

With a stability of output under temperature change greater than that of the standard cell it replaces, the CMC (Control Methods Co.) Current Standard (Fig. 9) delivers direct current to replace dry cell batteries in industrial as well as laboratory instrument systems. The CMC Current Standard compensates supply voltage variations to better than 0.001% per volt. Temperature variations are compensated to better than ±0.05% over a 70° to 140°F range.

Supplies are available in current ranges from 0-20 ma.

Principle is two-stage shunt and bridge regulator.

Designed for applications where load ranges are small, as in potentiometers.

Hays Corporation

One of the first Constant DC Reference Voltage Units was introduced by The Hays Corporation. Their Model 951:2 DC Reference Voltage Unit can be used in potentiometer type recorders, bridge circuits, as a power supply for signal retransmissions, as a replacement of standard or dry cells, etc. (Fig. 10).

The unit incorporates two stages of voltage stabilization plus a supply transformer and silicon bridge rectifier. The first stabilizing stage consists of a highly stable voltage reference tube. In turn, this tube acts as a prestabilizer for the second stage, a zener diode.

Stability of output voltage is ±0.05% for ±20% supply voltage fluctuations. Drift is ±0.08% maximum over 10,000 hours of operation (readjustable). Temperature coefficient is ±0.0045% maximum per C° change in ambient temperature.

Two standard units are available—(1) Output power 10 milliwatt maximum with 5 volts and 2 milliamp being the maximum limiting parameters. (2) Output power 50 milliwatt maximum with 5 volts and 10 milliamp being the maximum limiting parameters. Both units require constant load. They are similar in appearance as shown. Their dimensions are: 1⅞" x 2½" x 4", weight, 1 lb 3 oz.

Instrulab

Instrulab, Inc., offers the "Evenvolt" constant voltage unit (Fig. 11) as a replacement for batteries or batteries and standard cells. It features voltage regulation of ±0.04% for 20% voltage variation in input voltage at any one current. This excludes effects of temperature coefficient. Overall regulation is ±0.08% including effects of ambient temperature from 0 to 125°F.

Current output is either 5, 6, or 10 ma (depending on instrument with which it is to be used).

Principle is a 2-stage Zener and a bridge network.

Voltage output is adjustable from 1.019 to 1.045 V DC on Model 201 at currents from 5 to 10.0 ma.

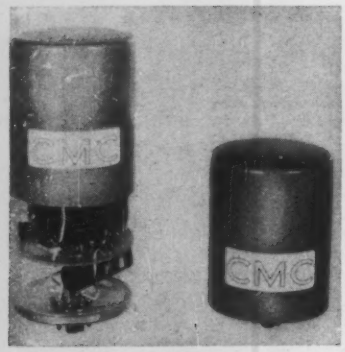


Fig. 9

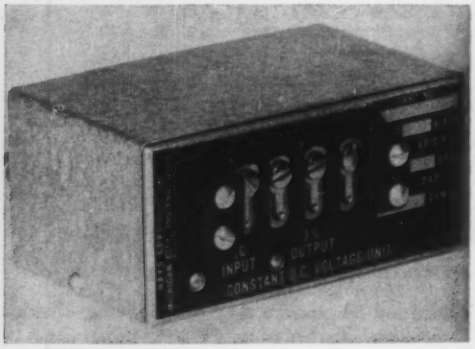
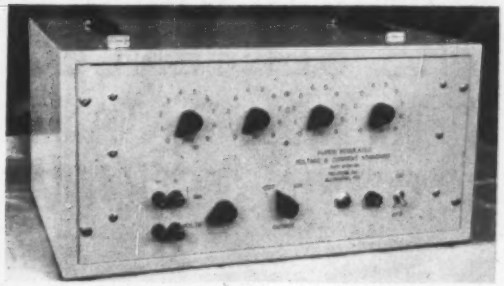


Fig. 10

Fig. 11

Radiation, Inc.

Radiation, Inc's super-regulated voltage and current standard functions equally well as a source of constant predetermined voltage or current. The four major parts include (1) main regulated power supply



of 250 v at 125 ma max, (2) reference regulated power supply of 250 v at 25 ma max, (3) normalizer, and (4) calibrator (Fig. 12).

The main power supply feeds the calibrators and the reference supply feeds the normalizer. When used as a voltage standard, the voltage drop across a group of high-precision resistors is used for reference purposes, while current is derived from the plate circuit of the calibrator. Two groups of resistors, one above and one below 10 ma, are provided in order to achieve maximum accuracy.

The normalizer derives basic information from a built-in standard cell, located where operating temperature variation is a minimum. The normalizer compares the voltage of this cell 60 times per second with a fraction of the normalizer output (111 v at 10 ma nominal). Any error appears as a 60-cycle square wave and is amplified, rectified in a phase detector, and used to correct the normalizer output to the proper value.

The normalizer feeds one 11,111-ohm 4-decade Varley-type voltage divider consisting of 51 precision wire-wound resistors on surface-treated switches with special silver alloy contacts, enclosed in a protective temperature-equalizing shield. The output of this divider is compared 60 times per second with the output of the calibrator and any error is corrected by means of a second square-wave amplifier and an additional

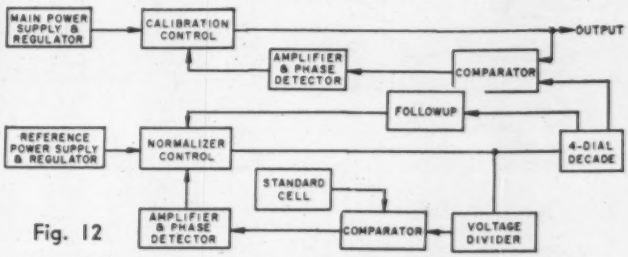


Fig. 12

phase detector. Further, a bridge circuit corrects the zero and differential residual error of the input to the electromechanical chopper. The precision wire-wound resistors (Karma) used in the calibrator are accurate to 0.05% and the standard cell is accurate to five significant figures. A factory adjustment sets the output to the nominal values with maximum accuracy and the shaft is clamped and sealed in place. D-c heater supplies and an auxiliary constant-current preloading power supply improve the accuracy and stability of the calibrator.

The drain of the standard cell never exceeds a few microamperes and drops to a fraction of a microampere when the unit stabilizes.

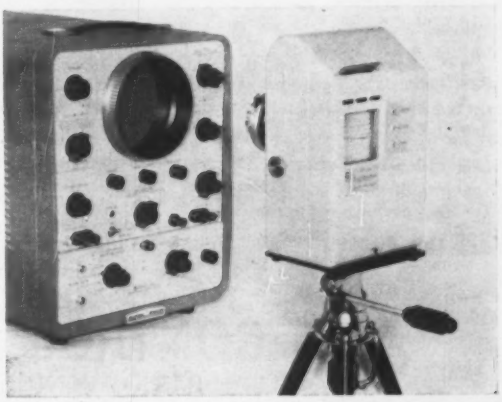
Output is 0-109.99 vdc (in 0.01 v steps), and 0-109.00 ma dc (in 0.01 ma steps). Accuracy is 0.05% of indicated output (or 0.005% of maximum output). Ripple is less than 0.08 mv at full voltage. Load can be as low as 1000 ohms at full-scale voltage; load can be as high as 1000 ohms at full-scale current. Input power is 105-125 v, 60 cycles, 150 watts max.

Addition to Camera-Recorder Survey

The 70-mm Rapid Processor of Photo Mechanisms, Inc., can photograph a scope trace (or document) and provides direct viewing in 9 to 36 seconds. It uses 70-mm Kodak SO-264 and Dacomatic films or Ansco Hyscan. These are blue-sensitive medium-speed emulsions. Shutter can be tripped manually or by solenoid.

The processing system uses a small pump with sealed fluid path, the only moving part. Two solutions are applied to the emulsion side of the film; the developed, fixed and dried negative needs only washing to be permanently stored. Solution tank provides for 45 minutes of continuous operation.

Maximum film speed is 5 inches per minute. Film may be advanced either continuously or frame by frame. Another model operates continuously for 2 hours at a maximum rate of 10 inches/min.



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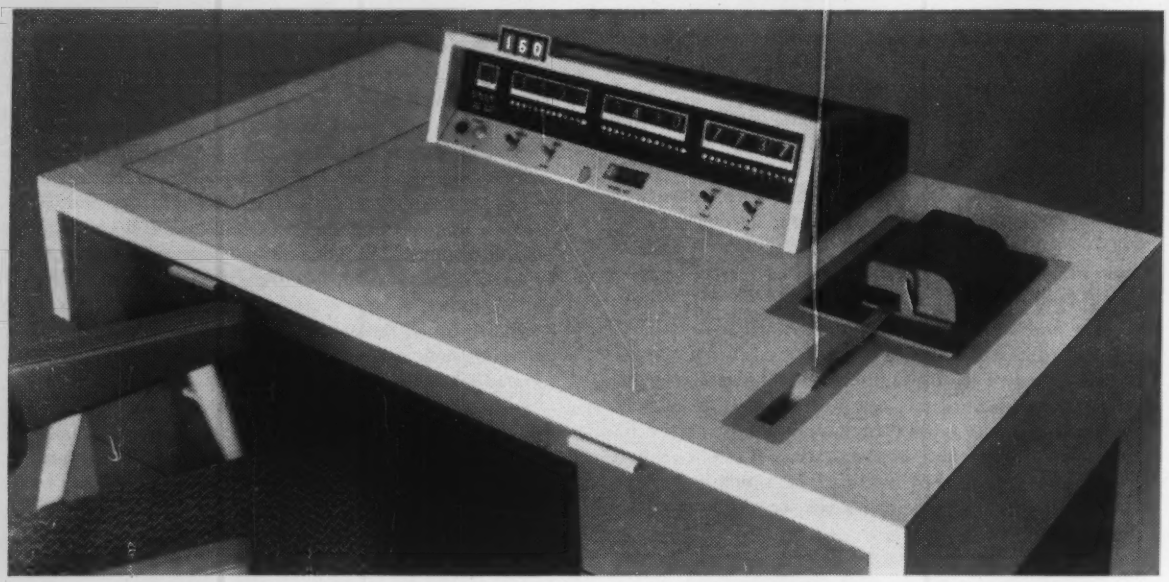

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2. OPERATING MODE: Operation controlled by an internally stored program. Single address logic, one instruction per word.

3. PROGRAMMING: Repertoire of 62 instructions. Ease of programming features flexible addressing modes — no address, direct address, indirect address and relative address. Complete programming package includes 22-, 33-, 44-bit fixed point arithmetic, floating point, complex floating point, decimal, floating decimal, and algebraic compiler.

4. INPUT-OUTPUT: Versatile instructions provided to handle available line of input-output devices: 350 character/second paper tape reader, 60 character/second paper tape punch, electric typewriter, up to 8 magnetic tape handlers (either 15KC or 30KC), card reader, card punch, and line printer.

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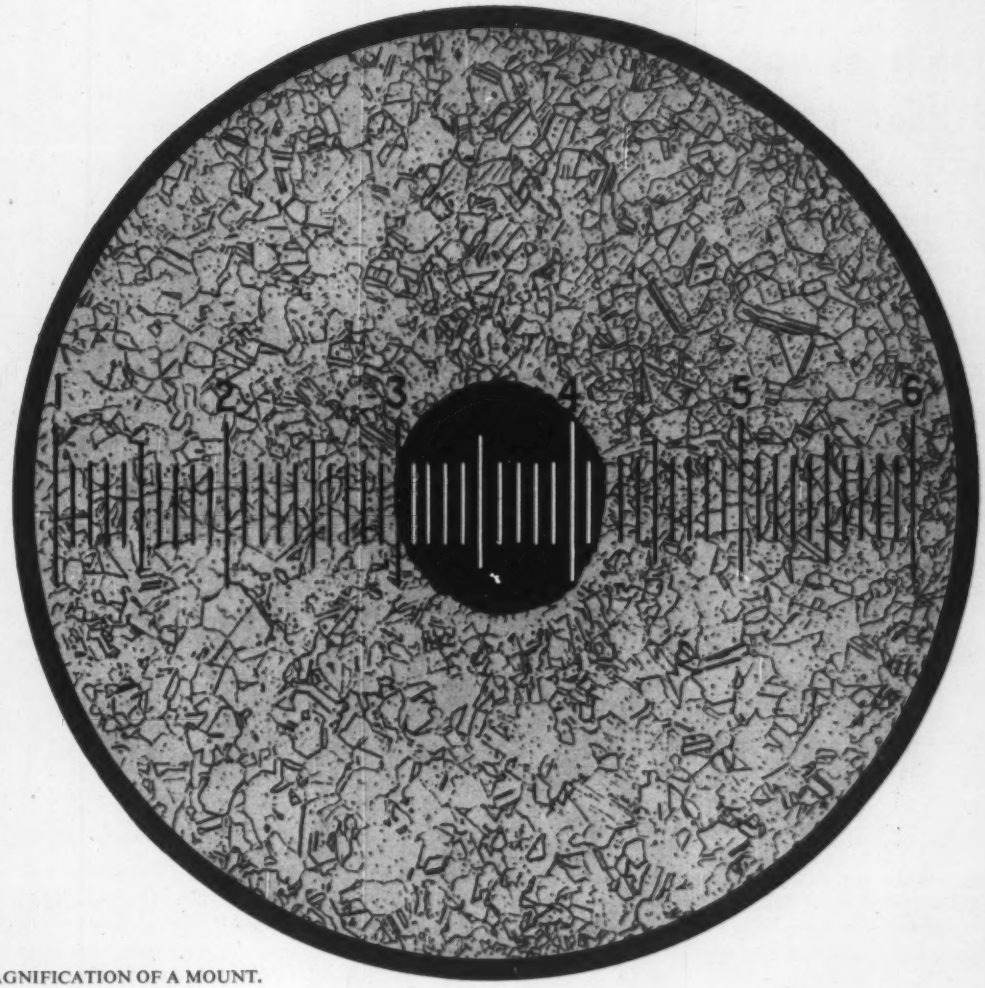

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CIRCLE 83 ON READER-SERVICE CARD

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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LACT for Oil Producers

Lease Automatic Custody Transfer (LACT) is the automatic metering and transferring of crude oil from the producing facilities to pipelines. Here are some LACT equipments finding increasing use.

WM. E. LACY
Black, Sivalls & Bryson, Inc.

CRUDE OIL now produced in this country is handled principally through a manual operation of sampling and hand-measuring of tanks by both the producer and the buyer prior to shipping the oil.

Oil or condensate as produced from the wells is not normally ready for immediate sale. Gas, water, sand, mud and some other undesirables must be separated at the lease. At present, the normal procedure is to store the oil in large tanks which are carefully measured for exact size. These tanks are sampled, tested, and gaged by hand, then shipped by pumping to the pipeline or to a tank truck. The process of gaging the tanks and sampling is then repeated by a representative of the pipeline or other buyers of the crude.

It is generally recognized that one of the largest costs of production is manpower. It also is generally recognized, but not always admitted, that the human error can be substantial.

Automatic Custody Transfer is not a new idea, but its acceptance in the oil field is relatively new. The largest force at work to bring about acceptance has been rising labor costs. Most of the major oil companies agree that automatic custody transfer is far more accurate; it is now being proved that it also is more reliable.

Several problems must be considered before installation of lease automatic custody transfer:

1. It must be completely acceptable to all parties involved in the buying and selling of the oil.
2. It must be sound economically and show a reasonably short-term payout. Most operators consider three-year amortization maximum.
3. It must be reliable in all kinds of weather.
4. It must be more accurate than the normal hand gaging.
5. It must be simple to service and repair, with downtime at a minimum.

Types of LACT Units

Crude oil produced in California varies widely in gravity, viscosity, vapor pressure, temperature and contaminants. Each of these characteristics demands special attention, not only in lease handling facilities, but also in selection and design of a custody transfer unit.

The API gravity ranges from 55 API condensates to the heavy 8 API crude of the coast area.

The viscosity is somewhat related to the gravity in that the high-gravity oils are extremely fluid, whereas the extreme low-gravity oils are so viscous as to be almost solid at ordinary temperatures; these heavy oils must be thinned by heating or by introducing dilutants.

The contaminants which are removed down to approximately 3% in lease facilities are gas, water, and base sediment. Those substances which are not removed on the lease, but which must be dealt with

as part of the oil (but which also represent some of our most troublesome operational problems) are wax and bitumuns. Therefore not all custody transfer units will be identical in type, size or complexity.

All LACT units, regardless of type, have essentially the same flow pattern and same basic requirements for complete and accurate operation (Fig. 1). Oil is received from the producing facilities, such as separators or emulsion treaters, to storage tanks to take up field surging. In some cases, weathering is necessary, and thus the size of the storage facilities may vary widely. Oil is then monitored for BS&W (bitumuns, sand and water) in lines which run to the LACT. If the oil is unsaleable, it is automatically rejected and must return to the treating facilities for further process.

The saleable oil is now in the AUTOMATIC CUSTODY TRANSFER unit where it is metered and recorded, and again monitored for BS&W, and finally shipped.

We now have two basic types of transfer meters:

1. *Positive-volume dump meter*, sometimes called Volumetric.

2. *Positive-displacement fluid meter*, often called P.D. Meters.

The entire lease may automated, in which event the LACT unit is integrated into the whole. However, it usually stands apart from other lease automatic systems.

Positive-Volume Units

In the positive-volume units, fluid is measured between inlet and outlet weirs in a vessel which is precalibrated at the factory and requires no further calibration providing there is no accumulation or foreign matter.

Metering is in the top half of the tank shown in Fig. 2. Oil fills this unit to the top weir, where it overflows and actuates an electric float switch. The upper float switch stops the fill delays a short period of time to allow gas bubbles to breakout. At the conclusion of this settling time, the weir valve opens and drains the excess oil down to the weir until a second float switch behind the weir is uncovered. This oil drains back to an overflow pot.

The dump valve is then actuated by the float switch behind the weir, and the entire volume is allowed to flow down into the dump. A level detector is actuated when all the oil has drained past the dump valve. A time delay is started in the controller to allow oil to completely drain from the meter.

At the conclusion of the time delay, the dump valve closes, and the overflow pot is allowed to drain into the meter. This is controlled on a timer. At the conclusion of the time delay to empty the pot, the upper valve on the pot is opened, and the bottom valve closed. This completes the cycle with the simultaneous opening of the fill valve. The sump holds 1¼ the total volume of the meter, thus allowing the outflow from the sump to the shipping pumps to be continuous. All valves are pneumatically operated with electrically controlled solenoid

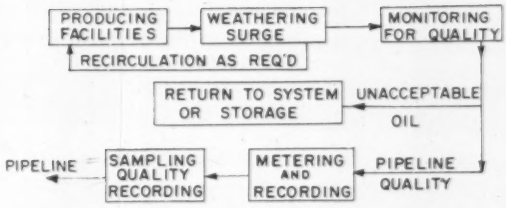


FIG. 1. BASIC flow diagram for LACT.

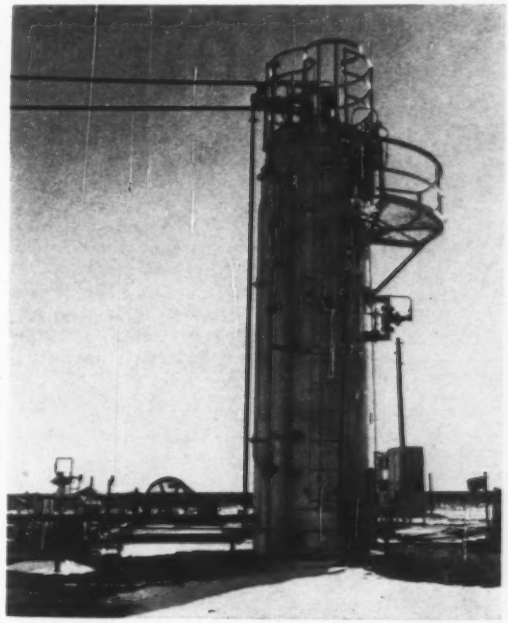


FIG. 2. THE POSITIVE-VOLUME dump (volumetric unit).

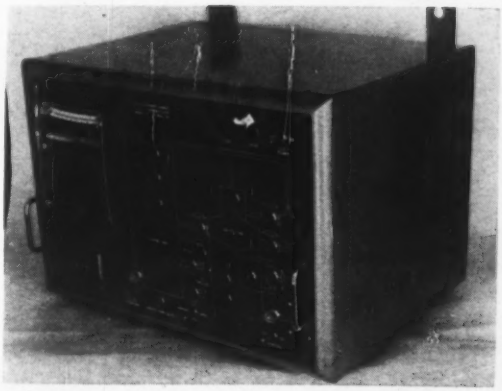


FIG. 3. CONTROL panel for positive volume LACT.

pilot valves. Interlocks are provided between fill and dump valves, between level controls on the surge tank and the meter inlet, and also between the pipeline pump and the sump tank.

The number of dumps are recorded and the temperature of each fill taken simultaneously. The temperature is then translated into a correction factor for expansion and applied directly to the volume of the dump.

Variations of this system are the all-pneumatic unit, electro-pneumatic unit, and all-electric unit, with the first by far the most practical and popular.

The control panel shown in Fig. 3 includes a flow diagram with signal lights that show which valves are actuated; thus the cycle can be followed. In the lower left-hand corner is the dump counter. A strip-chart recorder is in the upper left-hand corner. This records the temperatures and the fluid head in the meter. All of the valves on the unit proper are pneumatically powered, using local gas from the lease separators as a source of power. The electrical panel can be mounted any distance from the LACT unit or it can use repeaters with remote readout.

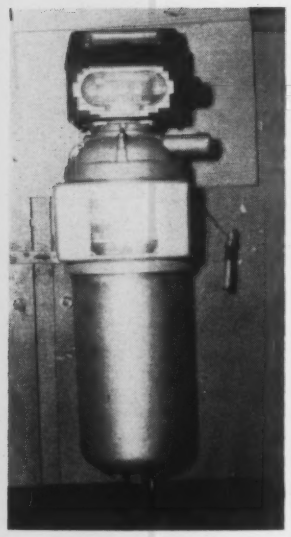
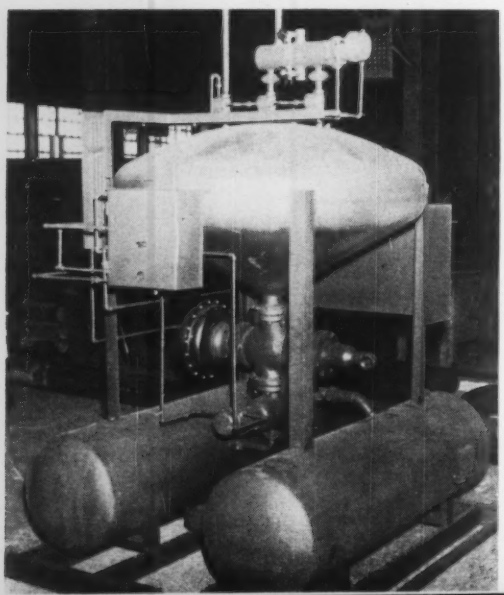


FIG. 4. TEMPERATURE-COMPENSATED volume recorder.

FIG. 5. SMALL positive-volume LACT unit.



In order to give a printed run ticket, it is necessary to have a temperature-compensated counter. Fig. 4 shows a meter that provides a rotational input proportional to the volume of each dump. This is corrected automatically for temperature by a mechanism which retards or advances the gear train.

The unit shown in Fig. 5 is an all-pneumatic positive volume unit used on small installations. No electric power is necessary. It is possible to have electro-pneumatic operation if desired.

The control panel (all pneumatic) is mounted directly on the meter as shown in Fig. 6. Oil enters the meter through the top 3-way 3-position valve. The upper float chamber valves are open and the bottom float chamber valves are closed. Oil continues to fill until the upper float chamber control is actuated, causing the valves in the float chamber to close and the fill valve to go to the neutral position.

The switching pilot then diverts the fill-and-dump valve to the dump position and opens the vent valve. The upper float chamber remains full until the entire meter is emptied. As the unit empties, the lower float chamber control is actuated, thus positioning the switching pilot to place the fill-and-dump valve in the neutral position and open the upper chamber valves which cause the oil to run back into the meter. As the upper float chamber control is uncovered, it actuates the controller to position the 3-way valve to the fill position and the cycle repeats.

This panel does not have the time delays as did the electro-pneumatic units. Because of its physical size, this is not normally required. The pneumatic system as shown is simply an arrangement of valve sequencing and overriding controls. It is not recommended for this unit to have a remote control panel as it would involve lengthy control lines and sluggish control.

Positive-Displacement Units

The *positive-displacement LACT unit* measures fluid by revolutions of a meter and is somewhat similar to the ordinary service-station gasoline pump. The energy to drive the meter is supplied by the pressure in the line. A fixed amount of oil is trapped between vanes in the meter and, in moving through the meter, turns the gears in a gear train to the counter. These meters can be automatically temperature compensated by a thermal mechanism which advances or retards the gear train in the proper proportion to the counter.

As positive-displacement meters measure the volume of a closed system, it is necessary to have a means of eliminating entrained gas bubbles from the oil. Thus, a separator or deaerator is installed to remove this gas. As the energy to drive the meter and its mechanism comes solely from the fluid pres-

sure, it is necessary to hold a back pressure on the entire system by means of a back-pressure regulator down-stream of the meter. This pressure must be in excess of the vapor pressure of the oil, otherwise solution gas breaks out in the meter due to the small pressure drop through the meter.

Normally, positive-displacement meters are calibrated at the factory, but variations in viscosity, and other flowing characteristics of the fluid tend to change the exactness of the meter. For this reason, and because the meters will show wear through mechanical friction, it is necessary to have a prover tank which is connected below the meter. This prover tank is a carefully calibrated tank which is filled and temperature compensated. Comparing this against the meter reading develops a meter factor to apply to future readings.

The control panel shown in Fig. 7 is an all-electric type which gives signals to solenoid valves mounted at control valves. The valves are all powered from an instrument gas system taking its supply from the lease separators. The control panel contains a BS&W monitor, relays to interlock switches, and motor starters. The flow-diagram signal lights indicate which valve, floats or switches are actuated. Run-programming clocks, as well as a preset counter may be included as required. The actual measure of the oil from this system is taken either by direct reading or from a printed ticket from the head of the P.D. meter.

LACT units are highly accurate and do a completely satisfactory job of metering. To keep a check on their accuracy, most units have a secondary system involving another P.D. meter with temperature compensator, a prover tank or, in some instances, a complete standby unit.

The comparative advantages are:

The positive-volume dump meters are not affected by foreign materials in the crude which would normally cause wear in the P.D. meters.

The accuracy of the positive-volume dump meter is independent of flow rate, whereas the P.D. meter operates at best advantages from 15 to 80% of rated capacity.

Crudes with high paraffin content do not offer any special problem for the P.D. meter, but may well cling to the inner walls of the volume dump meter, inducing an error. This disadvantage to the volumetric unit is somewhat offset by the use of coatings of certain plastic materials on the inner walls of the volume meter.

The P.D. meter type unit usually is less expensive.

New Development in LACT

LACT units should be completely automatic, yet it is necessary to have sampling and monitoring to determine the quality of the oil. The sample taken must be collected and analyzed for water and base sediment; this is essentially a manual operation. In time, automatic recording monitors will be developed to make these units completely automatic. In addition, suitable automatic computers which take into account correction for meter factors, temperature factors, and water content corrections will someday give us a complete unit free of all manual attention except for routine checks.

At present, LACT units of the electro-pneumatic type are being integrated into total lease automation. Transmitting units are being developed and used to send information over wires to a central location such as production headquarters. This information employs a scanner which reports periodically, in sequence, information from various points such as temperatures, well production data, gas being produced, pressures, and a report from the LACT unit with amount of total oil being sold. This information can be received on an ordinary teletype machine.

Practically all major oil companies have expressed their desire to use LACT, and some have gone to great effort to help in their development.

Bibliography

Morgan, Ralph A., "LACT will Work For You," Proceedings West Texas Oil Lifting Short Course, Texas Technological College, April, 1959, Lubbock, Texas.

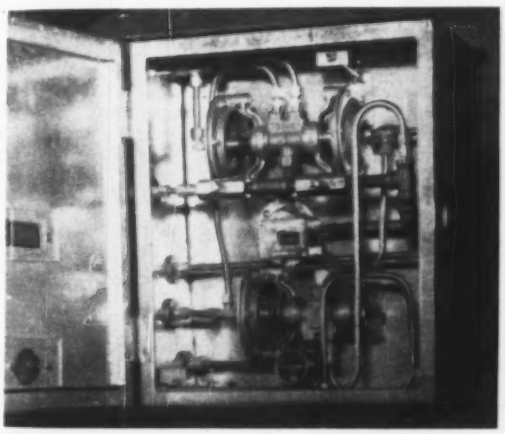


FIG. 6. CONTROL unit for small pneumatic LACT unit.

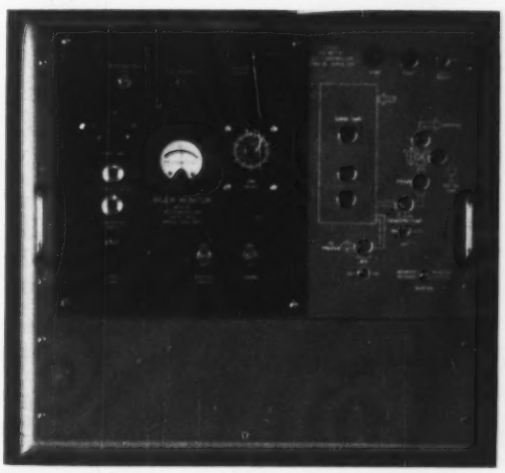
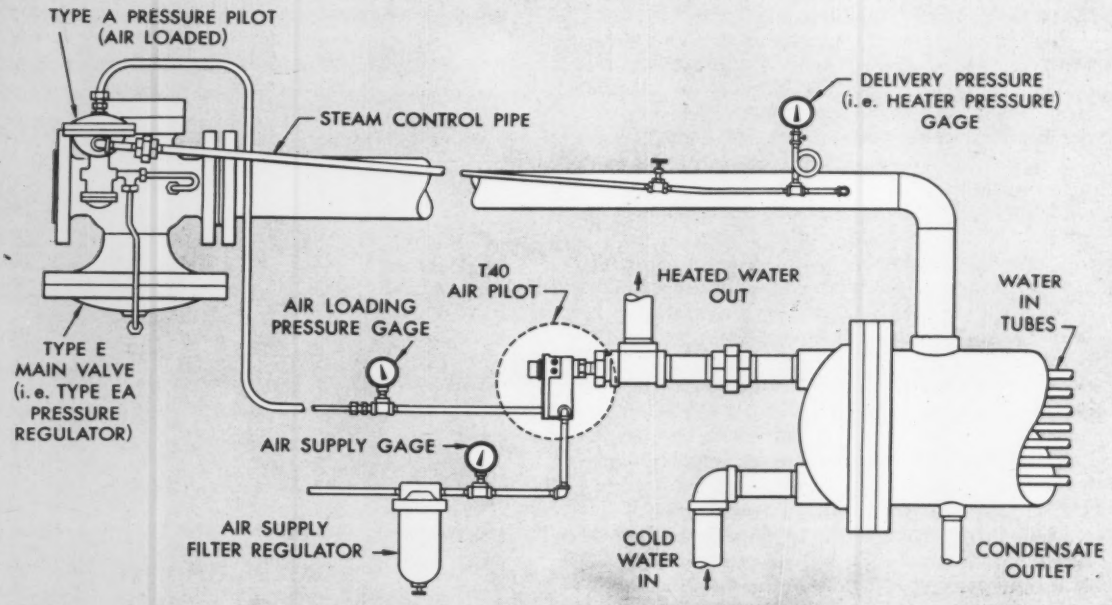


FIG. 7. CONTROL PANEL for positive-displacement LACT unit.

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs



TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York

SE-148A

CIRCLE 84 ON READER-SERVICE CARD

Veeder-Root READOUT Bulletin

One of a Series

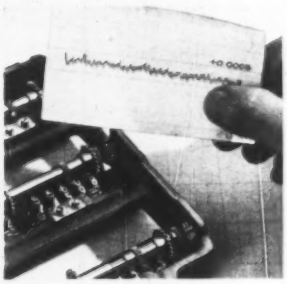
New "White Room" Assembly Insures Accuracy, Reliability of Instrument Counters

This special facility has been designed to provide positive environmental control for ultra-precision assembly and test of Veeder-Root Instrument Counters. Temperature and humidity are constant and electrostatic filtering and pressurization maintain air purity.

This is the latest step taken by Veeder-Root to insure top reliability and accuracy in counters and readout devices used for instrumentation, aircraft and navigational applications. Veeder-Root offers an extremely varied line of these instrument type counters; and also does extensive design and prototype work to develop new devices for all types of readout problems. Whatever your needs for precision counting devices, Veeder-Root can provide that extra margin of dependability by supplying a single counter or complete counting package or system. Your specifications will receive prompt attention.

Veeder-Root Precision Gearing Provides Long Life, Accuracy at High Speeds

The secret of Veeder-Root precision counter performance is the close tolerance manufacturing and inspection of gearing, typified by the strip chart record shown here. This Veeder-Root experience with all types of intricate gearing, to Precision Class 2 tolerances, assures accuracy and dependability in readout devices and counting packages.



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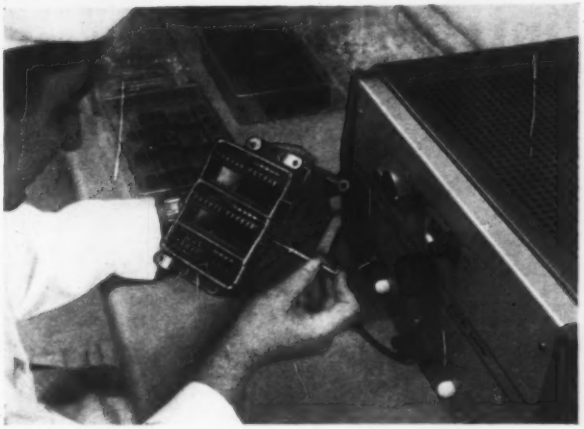


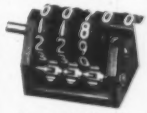
This is a Veeder-Root Counting Package developed for airborne navigational systems. It is being assembled and tested in the new "white room".

Series 1597 Miniaturized Counter

designed for readout of navigational data. Features maximum figure size on ½" wheel, plus small overall dimensions and light weight. For high speed counting.

Series 1698 Internal Pinion Counter

developed for aircraft instrumentation such as altimeters, fuel readout and manifold pressure. Wheels are only 0.672" in diameter.



Series 1392 Open Frame Counters

for navigational computers. Has extremely low torque, wheels are ball-bearing mounted, and counter is available with various frame styles for mounting into "packaged" systems.

Series 1666 Precision Internal Pinion Counter

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TYPE 504	525

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TYPE 503

The Type 503 is a differential-input X-Y oscilloscope with the additional features—linear sweeps, dependable triggering, sweep magnifier, bright trace, amplitude calibrator—desirable for general-purpose applications.

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dc to 450 kc

VERTICAL AND HORIZONTAL AMPLIFIERS
Differential input at all attenuator settings.
1 mv/cm to 20 v/cm in 14 calibrated steps.
Continuously variable between steps, and to approximately 50 v/cm uncalibrated.
Constant input impedance at all sensitivities (standard 10X probes can be used).

SWEEP RANGE
1 μsec/cm to 5 sec/cm in 21 calibrated steps.
Sweep time adjustable between steps, and to approximately 12 sec/cm uncalibrated.

SWEEP MAGNIFICATION
X2, X5, X10, X20, and X50 Magnification.

AMPLITUDE CALIBRATOR
500 mv and 5 mv peak-to-peak square-wave voltages are available from front panel.

3-KV ACCELERATING POTENTIAL
5-inch Tektronix crt provides bright trace, 8-cm by 10-cm viewing area.

EASY TRIGGERING
Fully automatic, amplitude-level selection on rising or falling slope of signal, or free-run (recurrent). AC or DC coupling, internal, external, or line.

REGULATED POWER SUPPLIES
All critical dc voltages electronically regulated, plus regulated heater supplies for the input stages of both amplifiers.

SIZE AND WEIGHT
13½" h, 9¾" w, 21½" d—approximately 29 lbs.

TYPE 504

The Type 504 has the basic features desirable for most general-purpose applications — sensitive vertical amplifier, linear sweeps, easy triggering, amplitude calibrator.

FREQUENCY RESPONSE
dc to 450 kc

VERTICAL AMPLIFIER
5 mv/cm to 20 v/cm in 12 calibrated steps.
Continuously variable between steps, and to approximately 50 v/cm uncalibrated.
Constant input impedance at all sensitivities (standard 10X probe can be used).

SWEEP RANGE
1 μsec/cm to 0.5 sec/cm in 18 calibrated steps.
Sweep time adjustable between steps, and to approximately 1.2 sec/cm uncalibrated.

AMPLITUDE CALIBRATOR
500 mv and 25 mv peak-to-peak square-wave voltages are available from front panel.

HORIZONTAL INPUT
0.5 v/cm, with variable attenuator.

3-KV ACCELERATING POTENTIAL
5-inch Tektronix crt provides bright trace, 8-cm by 10-cm viewing area.

EASY TRIGGERING
Fully automatic, amplitude-level selection on rising or falling slope of signal, or free-run (recurrent). AC or DC coupling, internal, external, or line.

REGULATED POWER SUPPLIES
All critical dc voltages electronically regulated, plus regulated heater supplies for the input stages of the vertical amplifier.

SIZE AND WEIGHT
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Rack-mounting models will be available, of course!

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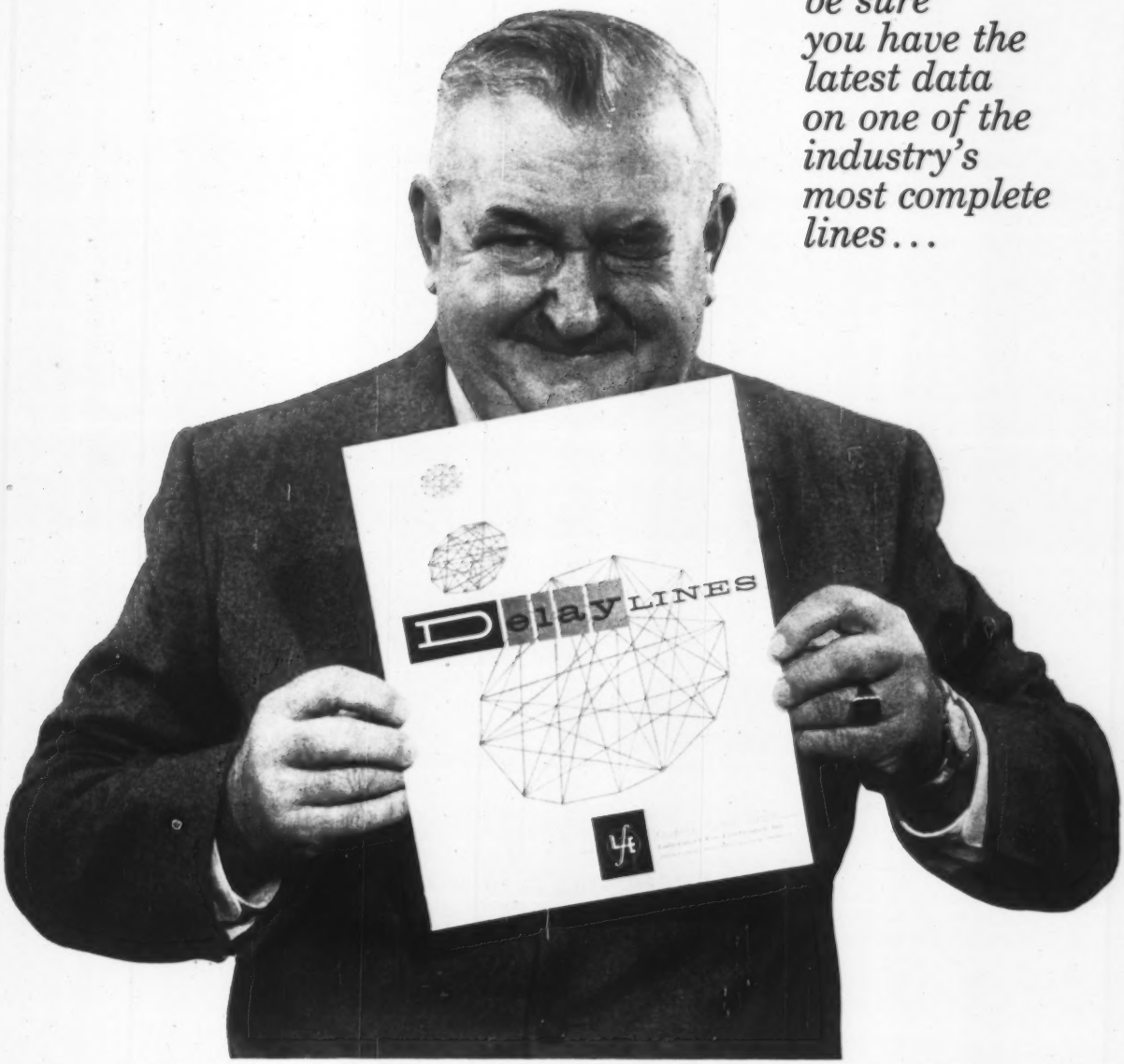

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Simply turn a dial to feed in design parameters, and the computer provides an instant by instant, dynamic picture of the effect of each change. You can study the inter-related effects of heat, pressure, flow, vibration, torque or any variable, and visually compare one with the other. Engineering data comes alive—insight into how new designs will work is obtained easier, faster.

Because of its minimum size and low price, the TR-10 can become your own personal analog computer. You gain first-hand experience with the power of analog techniques, and convert more of your time to *creative engineering*. New ideas that were too costly to try before are now practical. You can design virtually to perfection and have a permanent, visual record of performance before building pilot models or prototypes. As a result, "cut and try" expense is reduced.

The same quality workmanship and design that has made Electronic Associates the world's leading producer of precision general purpose analog computers will be found in this new unit. Accuracy to ±.1 per cent. Modular construction allows you to select varying quantities of the following computing functions: summation, integration, multiplication or division, function generation, parameter adjustment, logical comparison.

For complete engineering data, write for Bulletin TR-10-DA.

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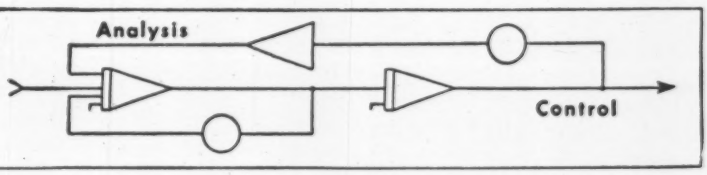
The SIMULATION COUNCIL Newsletter



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8484 La Jolla Shores Drive,
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Letters (not necessarily simulated)

"Dear John:

"Your question 'what do my readers want' prompts this answer from me: "An editor should try to find out what his readers want by asking questions like yours—*but* always keeping in mind:

"1. The answers are always from a tiny minority of the readers.

"2. There is no guarantee that those interested enough to reply are a representative cross-section of the readers.

"3. There is some evidence that the interests of the silent majority are usually far different from those of the heard-from minority.

"4. The final decision must be based on the needs of the majority of readers *as interpreted by the editor.*

"Ask your question to *help* you make up your mind, but not to make up your mind for you.

"As a personal example of pertinence: when the *Newsletter* was first included in *Instruments and Control Systems*, the primarily industrial readers of that publication had little interest in or knowledge of analog computation and simulation. The simulation men had perhaps even less interest in instrumentation.

"Yet the editor of *Instruments and Control Systems* realized that simulation is the heart of 'systems engineering'; that if one does not know enough about a system to simulate it, then he can do no effective systems engineering; that if one does know enough about a system to simulate it, then simulation is the most efficient way to synthesize and analyze a system. This editor concluded that his readers *needed* the Newsletter and they got it! No questionnaire alone could have produced the proper answer.

"Today steel mills, process plants, instrument manufacturers and a hundred other industrial operations use analog computers. The best type of 'systems engineering' in the country is being performed on these computers. Bringing the *Simulation Council Newsletter* to 30,000 industrial readers, month after month, year after year, must of necessity have contributed to this development.

"Cordially,
"*INSTRUMENTS AND CONTROL SYSTEMS*
"*Milton H. Aronson*
"*Editor*"

Bits

This month, besides the foregoing letter, we give you under Pieces some comments on the Western Simulation Council's Sausalito meeting last September, plus a more complete coverage of the joint Central and Midwestern Simulation Council meeting at McDonnell Aircraft in October.

At the latter meeting on "Management of Computing Facilities" *Ted Bellan* (McDonnell Aircraft) discussed "Integrating Technicians and Professionals into a Smoothly Working Computer Team"; *Ken Tuttle* (Beckman Computing Center, Los Angeles) gave a review of a "Symposium on Management Integration of Entire Computing Facilities"; *Ted Williams* (Monsanto Chemical) described "An Analog Computer Facility for Process Controls"; and *Milt Warshawsky* (WADC, Ohio) gave some information on his approach to the equipment, organizational, and personnel problems.

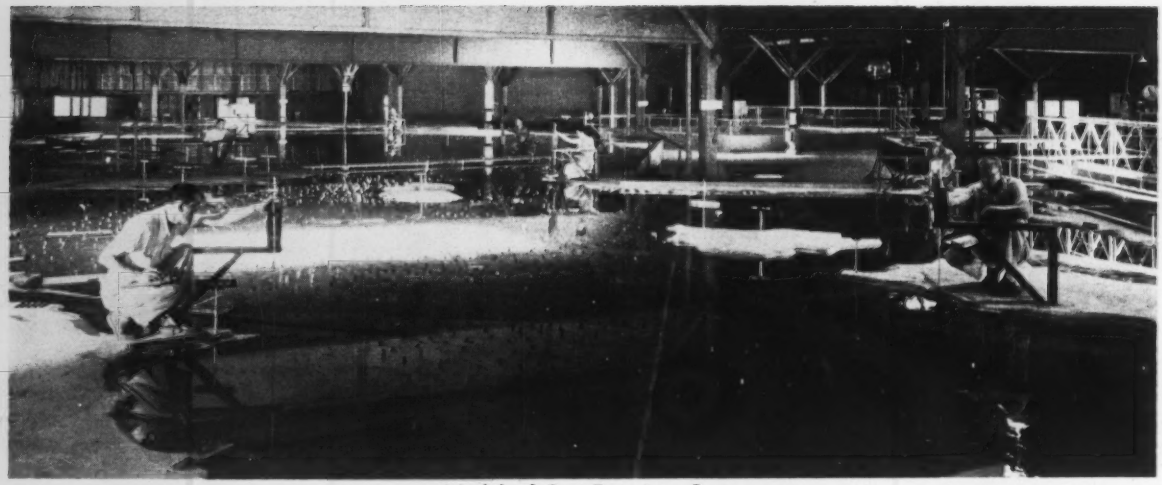
Pieces

WESTERN S/C MEETING OF SEPT. ON DESK-TOP COMPUTERS

Way back in September 1959 the Western Simulation Council had a meeting at the U.S. Army Engineers' San Francisco Bay Model at Sausalito, California at which they saw physical simulation on a large scale.

Your Ed. was not able to make this meeting, and aside from vague reports of "fine meeting" the only info I have been able to get is given in the following excerpt from a letter from *George Bekey* (Space Technology Laboratories, Los Angeles 45, Calif.), Chairman of the Steering Committee of the Western SC.

"The panel discussion was on the future of the desk-top computer. The speakers were *Dave Taskett* (Donner Scientific Co., Concord, Calif.), *Dave Miller* (Colorado Research Corp., Broomfield Heights, Colo.), and *Bob Wieneke* (Elec-



Model of San Francisco Bay

tronic Associates Inc., Mt. Prospect, Ill.). Warren Shepard of Litton Industries was unable to come, and therefore the DDA was left out of the discussion completely.

"As might be expected, both Wieneke and Taskett thought that the desk-top analog computer had a great future. The major differences of opinion between them had to do with the necessity for making the computer transistorized. Dave Miller, on the other hand, felt that the desk-top computer, while useful as an educational tool, did not serve a useful function for engineering computation since one usually finds that realistic problems require a larger capacity and more non-linear equipment than the desk-tops can provide.

"Furthermore, Dave thought, by the time a desk-top computer is provided with non-linear components and output equipment, it will approach the price of a full-size computer yet have the limited capacity and accuracy of a small computer.

"A rather hot discussion as to what is meant by "desk-top" followed. Some participants contended that a computer that completely covers the desk, not even leaving room for a pencil, can still be considered desk-top.

"Everyone parted on friendly terms. I am enclosing a brochure* of the San Francisco Bay Model where the meeting was held, which describes some of its features. The tour of the model was certainly one of the high points of the meeting, which was attended by approximately 40 people."

COMBINED WS/C AND CS/C MEETING OF 5 OCT ON "MANAGEMENT OF COMPUTER FACILITIES"

Between 50 and 60 people attended the joint meeting of the Midwestern and Central Simulation Councils at McDonnell Aircraft Corporation in St. Louis on 5 October 1959. The topic for discussion was "Management of Computing Facilities, Administration, Environment, Staffing, and Scheduling." *Don Augustin*, host for his company, introduced the first speaker, *Ted Bellan* (Manager of Computing Facilities and Don's boss). Ted delivered the official welcome for McDonnell Aircraft, then sailed into a talk on the day's topic, "Integrating Technical and Professional into a smoothly-working computer Team".

Bellan on Computer Team Integration

By way of introducing his company Ted told about an experience of their Chief Production Engineer. It seems that while flying out to Denver several weeks previously, the Engineer got into conversation with his seat companion.

"Who are you with?" asked the companion.

"McDonnell Aircraft" answered the Production Engineer.

"McDonnell Aircraft—who are they?".

"Why, the aircraft manufacturer in St. Louis."

(The companion *had* heard of St. Louis.)

"We are the largest employer in the State of Missouri", the Production Chief let it be known.

"You are? What do you build?"

"You've heard of Project Mercury? The space capsule built for putting a man into orbit?"

"Yes."

"We are building the capsule!"

"You are? Amazing! What else do you build? Is this just a new company?"

"No, McDonnell is 20 years old. In fact, it was 20 years old on the 5th of July this year."

Ted went on to explain that the company was organized in 1939 by J. L. McDonnell, who was Project Engineer with Glenn L. Martin until he decided that the only way to make any money was to go into business for himself. He had some good ideas aircraft-wise and has built the organization from a two-person operation (he did have a secretary) to the present employment of 24,000.

Some of McDonnell's products (in addition to the Mercury capsule!) were pictured along the south wall of the meeting room: the F2-H Banshee, a two-engine helicopter, an experimental ram-jet helicopter, the F-85 (a parasite fighter), the flying crane helicopter, the F-101 Voodoo, F3-H, the Talos missile, and some experimental aircraft.

Ted said a few words about the current production of the F4-H, advanced models of the F-101 and the Model 119 small utility jet transport.

"You will see these production lines," he continued, "have lunch in the Engineering Campus cafeteria, and visit the computing facilities. You won't get to see quite all of the computing facilities; you will see the facility of the Applied Mathematics Department which is the Engineering Computing Center.

"The main center is in the Engineering Campus where there are both analog and digital facilities.

*An exceedingly interesting brochure. Available from U.S. Army Engineer District, 180 New Montgomery St., San Francisco, Calif.

There is an additional analog-computing facility in our Laboratory Campus located about ¾ of a mile to the east. And about 700 feet due west and up four flights is a digital facility that services our Flight Test Facility.

"These facilities include a wide variety of equipment; a 240-amplifier PACE analog computer in the Engineering Campus matched on the other side of the aisle with an IBM-709; the SEAC, a direct-analogy analog computer; 80 amplifiers of REAC that date back about seven or eight years and 70 amplifiers of Beckman EASE equipment in the Laboratory Campus."

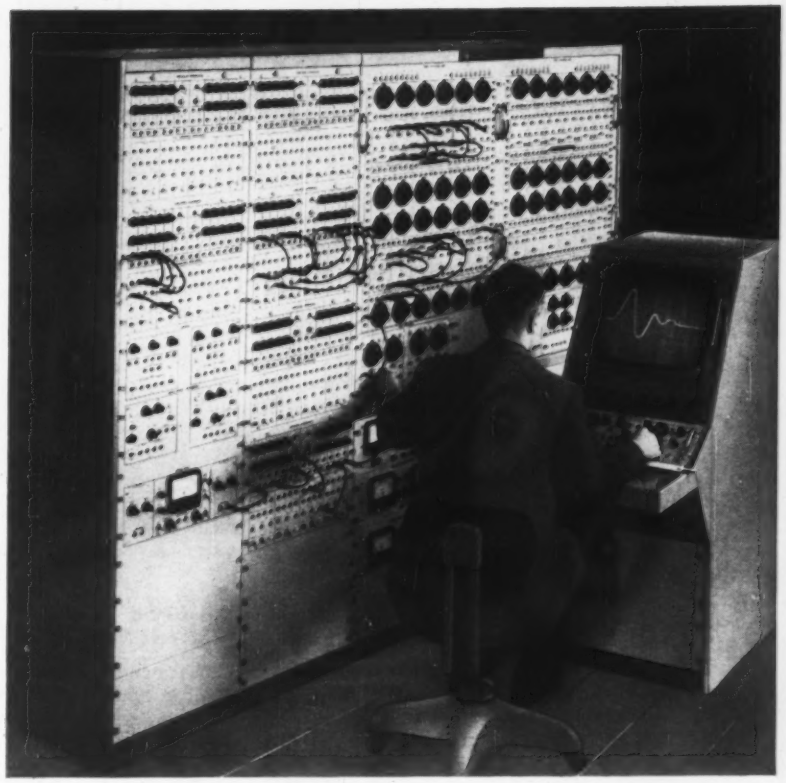
Concerning the integration of technicians and professionals Ted said, "When we talk about a computing facility we ordinarily think of the effort beginning in Engineering with the engineer and a slide rule. Then some bright young engineer comes along and says, 'I'm a very lazy individual, this slide rule is getting too heavy to push around, and what's more Company X over here has a device which will enable me to get seven or eight times the number of problems out in 1/10 the time, and with very little effort.' Or there is the possibility that a member of management will stop in at some other company and learn that they have a computer that they're really using successfully and profitably. So he comes back and says, 'Why don't we have such a device?'

"Anyway, some bright morning somebody wakes up and says, 'Say there's a series of crates out on the loading dock. It's an analog computer. What are we going to do with it?'

"This puts those of us who have the job of establishing the organization in quite a bind. In less than a week we have to set up a facility, staff it, and start running problems. We all know that this is an impossibility without some prior planning. But we do have some pipe dreams of our own as to how this organization *should* be established.

"Sometimes planning occurs at one level and implementation at another. Then unless there is good communication between the two levels each goes merrily about his task and wonders why the operation isn't successful.

"One of the prime problems in establishing a good working computer team is to establish a good line of communication in both directions. Many times the education up the line from the working individual is much more important than down from the management level.



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- *Radar systems in general*
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*An analysis of a missile miss-distance was conducted at the GPS COMPUTER CENTER by the research laboratory of a large aircraft firm. Their report stated that, "25 times as much data (with higher confidence-level) was collected in one week on the GPS computer as was collected and analyzed in 4 months time on a slow-speed computer"

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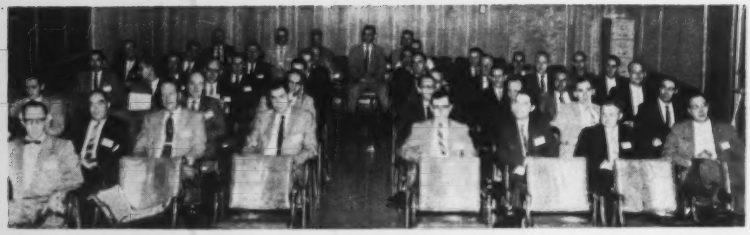


Joint Central and Midwestern S/C Meeting of 5 Oct. at McDonnell Aircraft Corp.

"Ideally some one should study what is required not only from the standpoint of equipment but from the standpoint of personnel. Can you staff and justify on the basis of work rather than on the basis of desire? (All of us have great dreams!) And then, what political problems will you have? How do you integrate this organization so as best to provide service for your company?"

Ted went on to say that he wouldn't be able to answer this question—not that morning, anyhow—but would hope to give indications of how they have tried to accomplish this at McDonnell.

"Ideally, if you could bring your people up through the maintenance and operating areas, rounded—well rounded—in the problems of the facility, and then advance them on into highly technical analysis area, you could in theory build and maintain a very skilled organization.

"Many of the problems that arise in integrating an organization are psychological. And I think that a great majority of these arise from such factors as 'Here is a degree man working right beside me, and he's doing the same work that I am, and I'm a technician. If I help him he's going to advance more than I will.' Can you educate your technician to realize that by helping the professional over the grade he may be stimulated into becoming just such a professional, acquire additional training, and in that way be of more value to the organization and also to himself?

"There's another problem—being willing to admit to yourself and to convey to your people that each position has a definite value to you and to your organization, and that it is your problem to try to build each to give the best over-all organization. You have to recognize that the various members of your staff who have differing educational backgrounds must be stimulated to advance into the other capabilities by training on your part and on their own.

"One solution to the problem is an interchange of personnel between areas. This has limited value in that you often can't just take the time necessary to train the men in the new positions. Another problem is the budget; you usually don't have the budget to spend on training."

Tuttle on Combined Analog and Digital Facilities

Ken Tuttle (Beckman Computation Center, Los Angeles, Calif.) next told of a "Symposium on Management Integration of Entire Computing Facilities."

"Some months ago," Ken said, "We had a meeting at the Beckman Computation Center on the problems of running an integrated computing center; by integrated we mean one with both analog and digital equipment. Our speakers were *Lec Ohlinger* (Northrop Aircraft, Hawthorne, California), *Ed DeLand* (Rand Corporation, Santa Monica, Calif.), *Bill Schart* (*Convair-San Diego*, Calif.), and *Dov Abramis* (*Con*Vair-Pomona, Calif.) I'm going to summarize this meeting for you as best I can.

"The problems of what personnel to get and how to use them, which *Ted Bellan* just discussed, received considerable attention. Specifically, one point arose from the well-known fact that mathematical and physical thinkers tend to speak two different languages; one of the problems in setting up a computer center to do engineering-type data handling is that of persuading them to get together.

"In the digital sphere of computer operation the closed-door, and perhaps even the ivory-tower, type of operation is fairly common. You bring your problem in, tell someone from the programming section what it's all about, and he says, 'All right, go away. Come back in a week and maybe I'll have an answer for you.' Actually the digital people have considerable justification for thinking that they just can't let any engineer start playing around with the machinery.

"In analog sections of computing facilities the closed-door is much less common because the engineer frequently wants to be on hand. And many people think he should be so he can evaluate the results as they actually become visible.

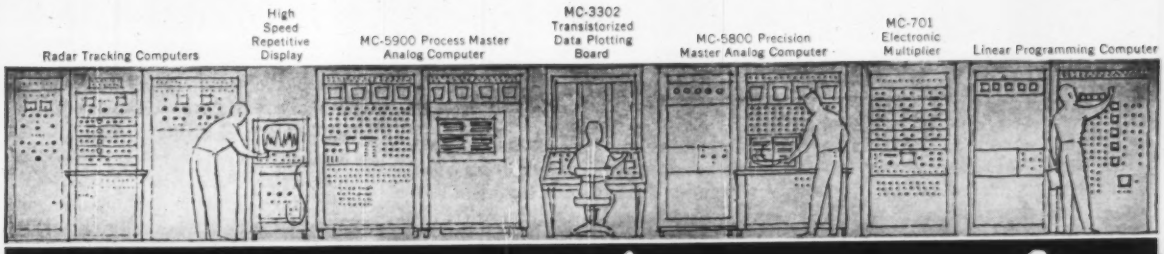
"Even in the digital sections it does a lot of good to have the engineer in as close touch with his problem as is possible while it's in the works. FORTRAN and languages of that sort are a big help in this regard.

"One thing that has been done in some facilities to increase the quality as well as the quantity of communication between those actually solving the problem and those who originate them and want solutions, is to hire—budget permitting—a sufficient number of men to assign some to work in the various engineering groups and become familiar with the problems of those groups. This has been tried in two or three facilities that I know of. With a reasonable amount of—shall we say—political care, it works fairly well. There is, of course, the danger that the person assigned to another area will decide he likes the work there better than his original work and request a transfer. But, if that is to be a problem, you're going to have to face it in some form sooner or later. You lose very little by making it possible for a man to find out where he wants to be.

"Most computing facilities have just grown—not only as to equipment, but as to forms of organization. In some places they use analog machines at first as a glorified form of slide-rule. In others they get the digital section first and then the analog possibly becomes a separate department.

"Unfortunately, it doesn't work well if you separate them entirely.

"A device that has been employed in some places is the transfer of men from one group to another to make everybody specialists, as far as possible, in both analog and digital machinery. This is difficult to do. There are few men capable of working with both concepts very successfully. But it can be done, and should be. One of the big problems in any computing facility, whether it's in two sections or under one administrative head, is to decide which form of computation should be employed. There are problems (I regret to say, being an analog man myself) that the digital computer will do better. And there are very definitely problems which can be han-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MC-5900 Process Master Analog Computer
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MC-5800 Precision Master Analog Computer
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DYSTAC (Dynamic Storage Analog Computer) synthesizes the advantages of both analog and digital computers. DYSTAC combines the analog's speed, lower cost, ease of programming, and improved output data presentation with the digital computer's unique capacity for data storage and time sharing of computer elements. With DYSTAC you can now solve the most complex problems, ranging from distillation column design to multi-dimensional heat transfer... from boundary value problems to transport lags.

In distillation column design, for example, DYSTAC employs only 44 amplifiers on a four-component problem; the number of amplifiers required is independent of the number of plates. With any other analog computer each plate must be reproduced in the circuitry—for a 30-plate column, over 1200 amplifiers are needed unless manual reprogramming is employed. What's more, only DYSTAC yields a plate-by-plate display of all column conditions.

In heat transfer studies, DYSTAC will speedily and accurately solve hitherto unsolvable partial differential equations. It also makes practical for the first time instantaneous solutions to such trial-and-error problems as automatic optimization, automatic correlations, data fitting, probability distribution, Fourier analysis, convolution and superposition integrals and eigenvalue.

When you buy a CSI computer with DYSTAC you are buying more than the finest general purpose analog computer. You buy additional capacity as well as capability. For when DYSTAC elements are not in use as memory devices they are available to the computer as operational amplifiers. Planning to interconnect digital and analog computers? DYSTAC is the answer.

See DYSTAC in operation at our plant. If you can't attend a demonstration write, phone or wire for full information.

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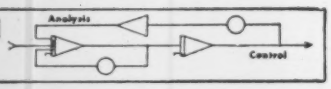


dled better on an analog computer.

"How do we assign a problem to one form of computation or the other? Once I was head of an analog section and a very good friend of mine was head of the digital section. It was our boast that our only arguments arose from trying to give the difficult problems to the other fellow! We weren't actually serious, but this reflects an attitude that is not uncommon. **So I believe that everybody in an integrated computing facility should be exposed to both methods of computing.**

"The policy determining how a computer facility should be run, however, is strongly influenced by the accounting department. If the facility is an overhead charge—a service organization—it's much easier in some ways to justify what you need. But it is more difficult in others: you're going to have to depend on your customer to bring work in to you and let you know what they're going to want next year. This is something that they may or may not be willing to do. I have seen occasions where people would set up within their own sections so-called computing coordinators with the idea that they would handle all of the problems of that group. They would serve as liaison between the engineering group and the computing facility. I have seen this grow into a rather horrible monster. On one occasion a fellow who was a computing coordinator decided that this was his opportunity to build an empire. He did everything he could to prevent the computing section from knowing what the work load was going to be on the basis that he preferred to hire new personnel for his group—sub-coordinators as it were.

"The question of what type of personnel to hire, however, is always an interesting one because we are not sure about the best type of men for computer jobs. At the symposium DeLand brought out some interesting facts.

"At Rand, and now at Systems Development Corporation, they have come to the conclusion that computer programming is a skill which can definitely be taught; whether a man learns it or not depends more on motivation than on innate skills. However, giving him that motivation is another matter. We don't know quite how to persuade a man that he should learn a certain thing, that he wants to learn it, and that it's a good thing to learn. We can only say that some people are good teachers; they inspire their students. There are psychological tests which have been used in selecting personnel, particularly for the digital field, but they don't seem to be working out very well.

"There are also differences in basic philosophy concerning the use of a computing center. Some people feel that computing is a broad field and the integrated facilities of digital and analog equipment should look forward to handling all computing, not just engineering computing. It's unreasonable, they say, to have a big machine capable of handling business as well as technical operations and not use it for both. Others feel that the computers in the engineering department should be used only as an engineering tool: to get solutions to problems. Still others contend that we will not be able to do a good job unless there are better ways to adapt the machine to the problem, rather than the problems to the machine.

"In short, the operation of a facility is, in my opinion, primarily a function of two things: the business structure in which it is imbedded and the personalities of those involved. That's about all you can say. There's always going to be a heck of a lot of playing by ear to get the job done."

Ken ended his talk on this note, and *Ted Bellan* asked: "What did you find the consensus was concerning the over-all question of integration?"

"That it is a very difficult thing to bring about, but it is something that has to be done," was Ken's answer.

Additional questions prompted Ken to remark that there is little difference between an applied mathematician and an engineer as far as computation is concerned, except in their response to a specific physical experiment: If the experiment fails the applied mathematician will conclude that there was something wrong with the experiment, while the engineer will question the mathematical theories which erroneously predicted the results!

Verne Larrowe (University of Michigan, Willow Run Laboratory, Ypsilanti, Mich.) commented that mathematicians will wire up an analog computer and expect the computer to provide the correct result, whereas engineers will approach the whole computer solution with a great deal of suspicion.

Milt Warshawsky (Wright Air Development Center, Ohio) remarked that experience at WADC has shown that the best analog-computer people are usually Electrical Engineers. However, as they could not be very selective in their hiring, some mathematicians were hired. Then these mathematicians tended to continue their formal schooling by taking graduate work in Electrical Engineering.

* * *

Williams on Process Computers

Ted Williams (Monsanto Chemical Co., St. Louis, Missouri) was the next speaker.

"At Monsanto we have essentially three computer organizations," Ted said. "There is what we call the Atomic Research Section, which has an IBM-702 and an IBM-650 RAMAC with additional tape storage. Then we have an IBM-704 with an 8,000-word core memory which is used for engineering problems and is operated by our Applied Mathematics Section. We also have a large analog computer operated by what we call the Theory Group of our Engineering Section. It is this last computer which I will describe this morning."

We will not give our readers the details of Ted's talk here because it was based on his paper, "An Analog Computer Facility for Process Control Analysis", the abstract of which follows:*

This paper discusses the size, component distribution, and other operating features of an analog computer which must be considered when setting up a facility for carrying out process-control and process-dynamics investigations. In addition, the numbers and required backgrounds of the personnel needed will be treated along with other pertinent factors.

Also for the benefit of those of you who are gadget-minded we would like to repeat one excerpt from that paper:

"One of the major present-day problems with analog-computer operation in the process industries is the difficulty of adequately representing a true time-delay. The development of a suitable and reason-

*An abstract of this paper appears on pages 618-619 of this issue.

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

How to Solve More Problems in Less Time

How Much Time Does a Computer Spend Computing?

As analog computing problems become more complex, more time is spent setting up and checking the electrical analog, and less time actually generating solutions. When we consider that actual computation sometimes occupies less than 1% of total computer time, it becomes evident that any method of speeding up or eliminating set-up and check-out tasks offers immense rewards —either by expanding problem-handling capacity or reducing the size and cost of an adequate installation. This month we wish to acquaint you with some of the time-saving techniques which have become practical with the introduction of digital control units.

A Device for Reducing "Non-Computational" Time

The EASE digital control unit, nicknamed the "DO/IT" system, is more formally known as the "digital output/input translator." Because we know it best and because we believe it excels in general utility, we will talk about ways of using the DO/IT. A number of the techniques are applicable to other digital control systems.

In case you are unfamiliar with the DO/IT, it is a mechanism for entering and retrieving information via typewriter and punched tape. Its essentials are a Flexowriter coupled to the computer through a battery of telephone-type relays. The relays actuate a digital-to-analog converter which, in turn, drives a servo-set potentiometer system. The DO/IT is capable of entering coefficient pot settings, commanding the computer to assume any operational state, and reading out values at any or all points in the problem-solving circuit. Although designed for EASE computers, the DO/IT will operate with other analog equipment.

Keeping this in mind, let us point out some of the techniques that have proved to be enormous time-savers at our Los Angeles Computation Center.

Eliminate Pot Set Error

The trick is to screen out errors before approaching the computer. A punched tape and typewritten record of pot addresses and desired coefficients is prepared in advance on a Flexowriter. This is checked and errors are corrected before entry. How about errors in the servo setting? These are more unlikely, but to insure that they do not occur undetected, the DO/IT prints out the actual setting after each command and conscientiously prints the setting in *red* if it deviates more than 20mv from the command value.

Locate Errors Quickly

"Debugging" the computer (that is, checking the electrical analog to be sure it corresponds to the equations being solved) is often a lengthy and tedious procedure. Errors in mechanization and patching are easy to make and sometimes difficult to locate. The best procedure is to calculate the value of selected variables under one or two static conditions, then test the computer to see if correct voltages appear.

For example, EASE 1100 Series computers have an operating condition known as "Static Check." In this condition the problem-solving circuit is connected exactly as at the beginning of a computing run except that suitable voltages are substituted for the output of each integrator. Theoretical values under these conditions are calculated in advance from equations or from mechanization diagrams. The calculated values are entered on a punched tape together with instructions to compare these values with those existing in the computer. The DO/IT makes the comparison: if calculated and actual values agree, it prints nothing; if there is a discrepancy, it prints the difference. An operator, scanning the printed record, can immediately pinpoint errors in patching and mechanization – in addition to errors created by possible faulty components. As an added insurance against error, this test may be supplemented by a similar check under initial conditions and a check made after an arbitrary computing time under "hold" condition.

Because automatic scanning and printout makes it easy to check a problem set-up, operating personnel are inclined to make frequent tests. These tests often expose errors which would cost hours or days of computer time if undetected.

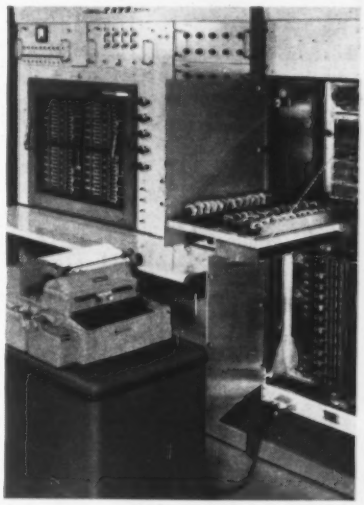
Program Survey Problems Automatically

In survey problems, equations remain essentially the same while a few parameters are changed from run to run. Solution of these problems can be speeded up by programing parameter changes on punched tape so that an entire series of computions will be run and recorded in rapid succession.

Run Two Problems "Simultaneously"

Problem handling capacity can be effectively doubled if two shifts of workers can use the same computer. Often this is impractical because one shift does not wish to destroy the set-up left by the previous crew, nor are they well enough acquainted with the problem to proceed with its solution. Punched tape entry and retrieval offer a way out of this dilemma. Each crew works on a separate problem. At the end of a shift, the people quitting work simply record all settings on punched tape and pull out the patchboard. Those coming on shift insert another patchboard and enter the previous day's setting via punched tape. In this way two projects can proceed simultaneously and without interference.

Write for further information on the DO/IT system, or better yet, see it in operation at our Los Angeles Computation Center, 305 Parkman Ave., Los Angeles 26. Kenneth Tuttle, Director.



The EASE digital control system, showing sturdy telephone-type relays which link flexowriter to digital-to-analog converter behind top panel.

C6

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ably-priced magnetic tape or drum mechanism for this purpose would be a major boon to the field."

* * *

The last speaker of the day was *Milt Warshawsky* (Wright Air Development Center). Milt literally spoke off the cuff as he described his large and most interesting analog-computing facility at WADC. However, as this was described in some detail in our January *Newsletter* we will not repeat ourselves here, except to say that Milt again emphasized that he considered rather sophisticated checking features a *must* for the modern large-scale computing center.

* * *

At the conclusion of Milt's talk the group made a brief tour of the McDonnell manufacturing facilities, where they saw four different kinds of airplanes being manufactured. Then they climbed aboard buses and rode to the Engineering Campus of the sprawling McDonnell facility. There are at least three different "campuses" of the McDonnell plant, and they are a mile or so apart. At the Engineering Campus the members of the Simulation Council were guests of the company for lunch.

Later the joint technical session was resumed for a panel discussion on the subject of the day, by three of the four speakers of the morning plus a substitute for Ted Williams, who had to get back to his own plant. (*Paul Parisot;* Group Leader at Monsanto's Analog Computer Lab).

Jim Pierce (Beech Aircraft, Wichita, Kansas) was panel moderator; he'd originally been scheduled for a talk but had to withdraw.

The first topic which Jim introduced was chilling! Two methods were discussed: cooling of the room where the computer is located, and cooling the computers directly. Apparently direct cooling is more efficient, but the general opinion was that this advantage is offset because it leaves the personnel hot under the collar! Usually management cannot be convinced that air cooling for the personnel is important, so the usual approach is to decide on cooling the room: Thus the personnel enjoy the side effects.

This elicited a question by *P. J. Hermann* (Goodyear Aircraft, Akron, Ohio) concerning the Care and Feeding of Management. "Are there any general rules for deciphering the moods and motives of Management?"

There was no answer from any of the panel or any of the participating audience. This question was raised several times later during the discussion, which proved somewhat embarrassing to *Ralph King*, who had persuaded the boss, one of the vice-presidents of Caterpillar Tractor Company, to attend the meeting. Fortunately the rabble-rousing was taken good-naturedly, in the spirit in which it was intended—to a spirited discussion.

There was some talk of open versus closed shop. The general consensus was that a closed shop was best, though some of the facilities represented allowed certain people outside the lab to operate the equipment. Only one facility, that represented by *Jim Wolle*, General Electric Co., Philadelphia, operates completely open shop. Jim's primary function is to maintain the facility, see that it's ready to go, schedule its operation, and help those who need it in setting up and operating their problems.*

Milt Warshawsky is an especially strong proponent of the closed shop. He feels that for greatest efficiency in the operation of a large facility it is imperative that it be completely closed; that the operation should be completely controlled and operated by computer lab personnel.

Jim agreed that education of outside personnel is a great problem in open-shop operation.

Financial recovery of facility costs came up for discussion, with the complete range of methods apparently about evenly represented at the meeting. Some companies (e.g. Goodyear Aircraft) try to recover all costs as direct charges against the projects serviced. Others, like McDonnell, charge labor directly to the project, but recover all machine costs (in the case of McDonnell a 240-amplifier analog, and an IBM 709 digital at around $66,000 per month) as overhead. Still others recover all costs, both labor and machine, as overhead.

After the panel discussion had been more or less forcibly brought to a close, the group made a tour of Don Augustin's analog computer facility. This includes relatively new PACE equipment with some of the more modern bells and whistles associated with a medium-large-sized computer.

*That's the way Astronautics works, and that's how it should be! Anyone want to argue?—Ed.

"If it can really do the work of a dozen Senators in a fraction of the time think of the terrible havoc it can wreak!"

He Went Thataway!

Duane Beecher to Elgenco, Inc. (Santa Monica, California).

Information (Without Theory)

We have just received our copy of the 1960 *Computer Handbook* and whaddayaknow? It starts off with articles on analog equipment and leaves the digital to bring up the rear.

However, regardless of anyone's personal prejudices we believe all will find in this handbook an excellent (ahem!)* selection of "How to do what with which" articles. (This handbook is available with a new or renewal subscription to *Instruments & Control Systems,* Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 12, Pa., but cannot be sold separately because of certain rules laid down by those powers who audit the circulation of journals.)

*Of course the fact that the first of these is by your Ed. has nothing to do with the fact that I think this handbook should be on everyone's computer bookshelf!

For engineering, for research, for business data processing in companies both large and small . . . **The new, fully-transistorized**

RPC-4000

ELECTRONIC COMPUTING SYSTEM

another outstanding computer value
. . . marketed by Royal McBee Corporation

Advanced design: fully transistorized—with important new computer design concepts that provide the largest memory, greatest problem-solving capacity and flexibility in the low- or medium-priced field. Entire system—computer, input-output typewriter and tape punch-read console—have been specially designed as a unit. **High-speed computing ability:** extra large capacity (8008 words) magnetic drum memory, with special fast access features. Computing speeds of up to 230,000 operations per minute. **Ultra high speed input-output:** 500 characters per second photoelectric punched paper tape reader, and 300 characters per second paper tape punch available as optional equipment. **Easy to use:** maximum results can be obtained by non-technical personnel. Users benefit from free training, continuing assistance, an extensive library of programs. Versatile command structure provides programming speed and flexibility. **Low in cost:** priced just above the small-scale computers, the RPC-4000 outperforms computers costing many times more. **Economical to install and operate:** no site preparation, air-conditioning or special maintenance required. Plugs into any standard wall outlet. **Multiple application ability:** designed to perform engineering, scientific and research calculations, as well as business data processing and management control functions.

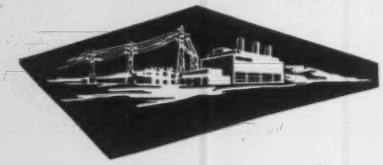
The RPC-4000 is a product of the Royal Precision Corporation, and is marketed by the Data Processing Division of Royal McBee. It is the latest member of the growing family of electronic computers from the people whose LGP-30 has become the world's leading small-scale computer.

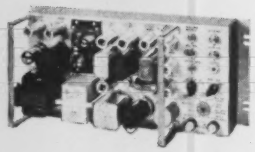
Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. RPC-4000 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For full specifications, write **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.

CIRCLE 92 ON READER-SERVICE CARD

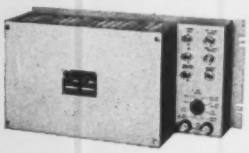
Telemeter
ANY VARIABLE
from Remote Points





MODEL 1025 Transmitter

MODEL 1090 Receiver



Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DErfield 4-3100.

Write for Technical and Application Data.

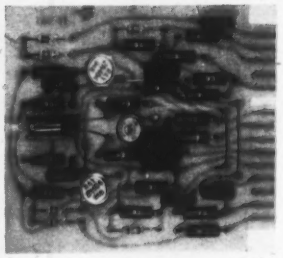
Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

CIRCLE 93 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

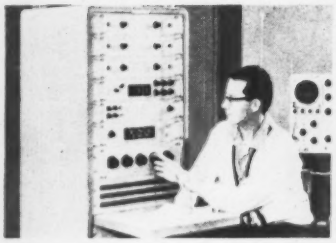
TRANSISTORIZED MODULES

New line of compatible transistorized Digital Modules features neon indicators on flip-flops and shift registers, and the allowance for use of a remote indicator. They are economically priced and completely compatible. Overall size is 3 1/16" x 3 3/8", with an approximate weight of 1.5 oz. Types include flip-flops, shift registers, multivibrators, one-shots, d-c logic, etc.—*Control Equipment Corp., 19 Kearney Rd., Needham Heights 94, Mass.*



CIRCLE 217 ON READER-SERVICE CARD

DIGITAL DEVIATION OHMMETER

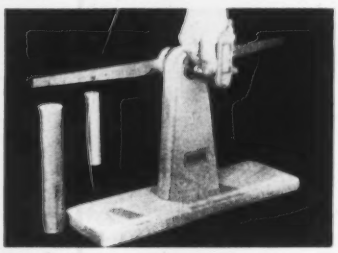


New Model DVM-300 Digital Deviation Ohmmeter automatically measures resistance around any selected nominal value and presents the information in digital form as a direct percentage of this value. Average balance time is 1 sec. Absolute accuracy is 0.01%. Particularly suited for automatic measurement of temperature coefficients.—*Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif.*

CIRCLE 218 ON READER-SERVICE CARD

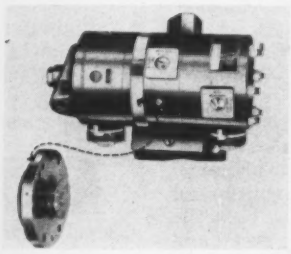
PRECISION TORQUE TESTER

New beam-type, dead-weight Precision Torque Tester is primarily for use with maker's precision-magnetic torque tools, but is equally useful for general checking of torque wrenches. Features include cast aluminum base, interchangeable accurately notched scale, double ball bearing-mounted shaft. Bulletin gives details.—*Stuart D. Paterson Co., Inc., Box 44, Rochester 9, N. Y.*



CIRCLE 219 ON READER-SERVICE CARD

BELLOWS-TYPE CONTROLLER



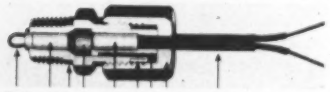
New Series-650 Pneumatic Controllers with metal bellows are recommended for batch-type processes with frequent startups, and for installations where ambient temperature is variable. Available with on-off; adjustable-proportional; proportional-plus-reset; fixed-proportional-plus-reset; and proportional-plus-reset, plus derivative control modes.—*Bristol Co., Waterbury 20, Conn.*

CIRCLE 220 ON READER-SERVICE CARD

FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 671 OR 705

MIDGET TC GLAND

New line of Midget Thermocouple Glands for #20- or #24-gage bare-wire thermocouples, only 1¼" long by



$\frac{3}{16}$" hex, provides a positive pressure seal from 0.005μ to 5,000 psig. Fitting can be furnished with or without thermocouple wires and is reusable. —*Conax Corp.*, 2300 *Walden Ave., Buffalo* 25, *N. Y.*

CIRCLE 221 ON READER-SERVICE CARD

MOBILE TEST BENCH

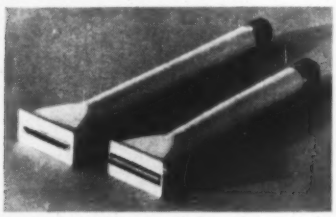
New Mobile Test Bench, which is completely adaptable to most checkout situations, consists of a basic bench

unit that can be mounted on rubber-tired and spring-suspended retractable undercarriage for mobility, a tool drawer, and adjustable shelves as required. Shelf assemblies are shock-mounted for protection of sensitive equipment. Besides all-weather protection, construction provides rounded corner and edge contours for safety.—*Skydyne, Inc., Port Jervis, N. Y.*

CIRCLE 222 ON READER-SERVICE CARD

ELECTRONIC PRINTER

New Printapix direct-printing CRT's (Types L-4013 and L-4016) employ a metallic element mosaic tar-



get or printing head in place of the usual phosphor screen. Tube provides printing or writing head 0.15" high to accommodate writing of complete characters or symbols across the entire head width of 2¾". Two-dimensional head may be used for sequential scan line (TV-type) operation. High definition is achieved through 0.001"-dia conductive elements and electron beam. Writing rates of 0.1 μsec per element are achieved. Uses an inexpensive and reusable base material and dry developer.—*Display Devices, Litton Industries, Electron Tube Div.*, 960 *Industrial Rd., San Carlos, Calif.*

CIRCLE 223 ON READER-SERVICE CARD

Welch DENSICHRON ©

ELECTRONIC DENSITOMETER

ASSURES QUICK, ACCURATE STABLE READINGS OF TRANSMISSION AND REFLECTION DENSITIES

Good Sensitivity—High Stability

NO. 3830A DENSICHRON AND PROBE

NO. 3832A REFLECTION UNIT

—SPECIAL FEATURES—

Patented Magnetic Modulation
Simple to Use
Convenient Small Size—5" x 7¼" x 13"
Light in Weight—only 11½ pounds

NO. 3830A. DENSICHRON WITH BLUE PROBE, including amplifier with logarithmic-scale meter, metal probe support, five different measuring apertures, a cone with ¼ inch aperture and a set of instructions. The amplifier operates on 115 volts, 60 cycle, A.C. only, except on special order ....**Each, $250.00**

NO. 3830B. WITH RED PROBE....Each, $265.00

NO. 3832A. REFLECTION UNIT. When coupled to the Densichron amplifier this unit becomes a convenient reflectance meter. It has a self-contained light source, filter wheel and phototube, and includes optics for both small and large spot work, a calibrated gray scale, and three Carrara working standards. .....**Each, $160.00**

Write for our new DENSICHRON catalog giving complete description on these and many other set ups and accessories.

W. M. WELCH SCIENTIFIC COMPANY

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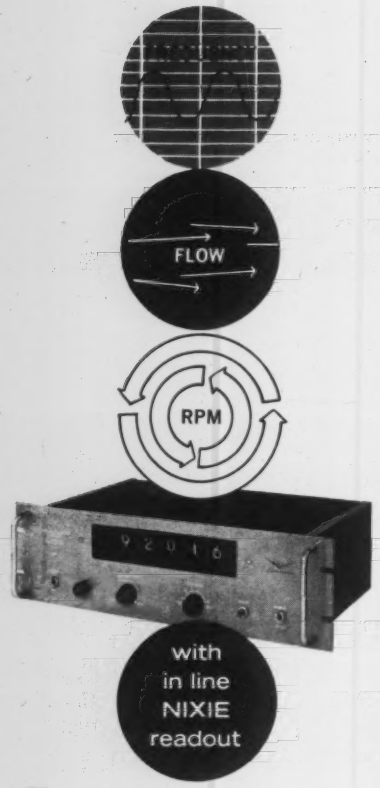
Manufacturers of Scientific Instruments and Laboratory Apparatus

CIRCLE 94 ON READER-SERVICE CARD



NEW low cost multi-purpose electronic counter

Model 720 events-per-unit-time counter is designed for uses requiring flexibility. Measurement of most physical variables such as flow, RPM, frequency or time interval is simple with NIXIE in-line readout, which reduces operator fatigue and errors. Low cost starts at $475 for 3-decade model. Send for technical literature.

DECADES:	3, 4, 5 or 6
FREQUENCY RANGE:	0 to 120,000 pulses/sec.
SENSITIVITY:	50 Millivolts RMS
ACCURACY:	± one count ± time base error
DISPLAY TIME:	0.2 to 6 sec. or infinite
SIZE:	19" x 5¼" x 12"
WEIGHT:	25 lbs.

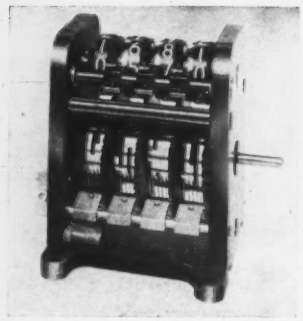
Manufacturers of digital counting and timing instruments and systems for military and commercial use.

ERIE
INSTRU/MATION

ERIE PACIFIC DIVISION
ERIE RESISTOR CORPORATION
12932 S. Weber Way, Hawthorne, Calif.
Phone: ORegon 8-5418

CIRCLE 95 ON READER-SERVICE CARD

DIRECT-READING A/D CONVERTER

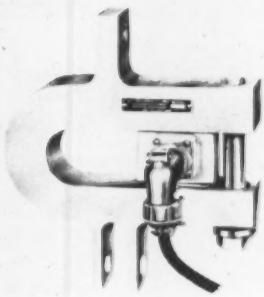


New Direct Drive Counter ADAC provides simultaneous readouts in both visual and digital form. It can be utilized as input to computers, business machines, tape punch recorders, card punchers, digital printers, servomechanisms, integrators, and meters. Typical characteristics include: input driving torque—2 in oz; input shaft rotation—250 rpm (max); digitalizing capacity—0000 - 9999; resolution—1 bit per 10,000 bits.—*Kearfott Co., Inc., 1500 Main Ave., Clifton, N. J.*

CIRCLE 224 ON READER-SERVICE CARD

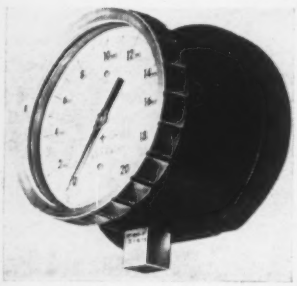
FORCE CONTROL SWITCH

New Force Control Switch for heavy duty service incorporates attachment eye and yoke integrally machined as part of the deflection beam. Switches contained in the housing at center are actuated at various pre-set load points by means of recessed adjustment screws located in the lower half of the beam. Miniature switches are completely enclosed in a dust and moisture-proof case fitted with an aircraft type electric coupling.—*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*



CIRCLE 225 ON READER-SERVICE CARD

HIGH-PRESSURE GAGE



New 6" Pressure Gage, available in twelve ranges from 1000 to 100,000 psig, has a specially-drawn and formed Type 316 s.s. multiturn helical Bourdon tube which has mechanically sealed ends to permit cleaning. Full-rupture Teflon diaphragm back, a high-tensile safety plate between the element and the viewer, and a laminated safety dial glass provide maximum safety. Divisions are spread over 300° on a dial for all ranges. Accuracy is ¼ of 1%.—*Astra Corp., Warminster Rd., Hatboro, Penna.*

CIRCLE 226 ON READER-SERVICE CARD

GLASS CYLINDERS
RODS · TUBES
CIRCLES & SPECIAL SHAPES

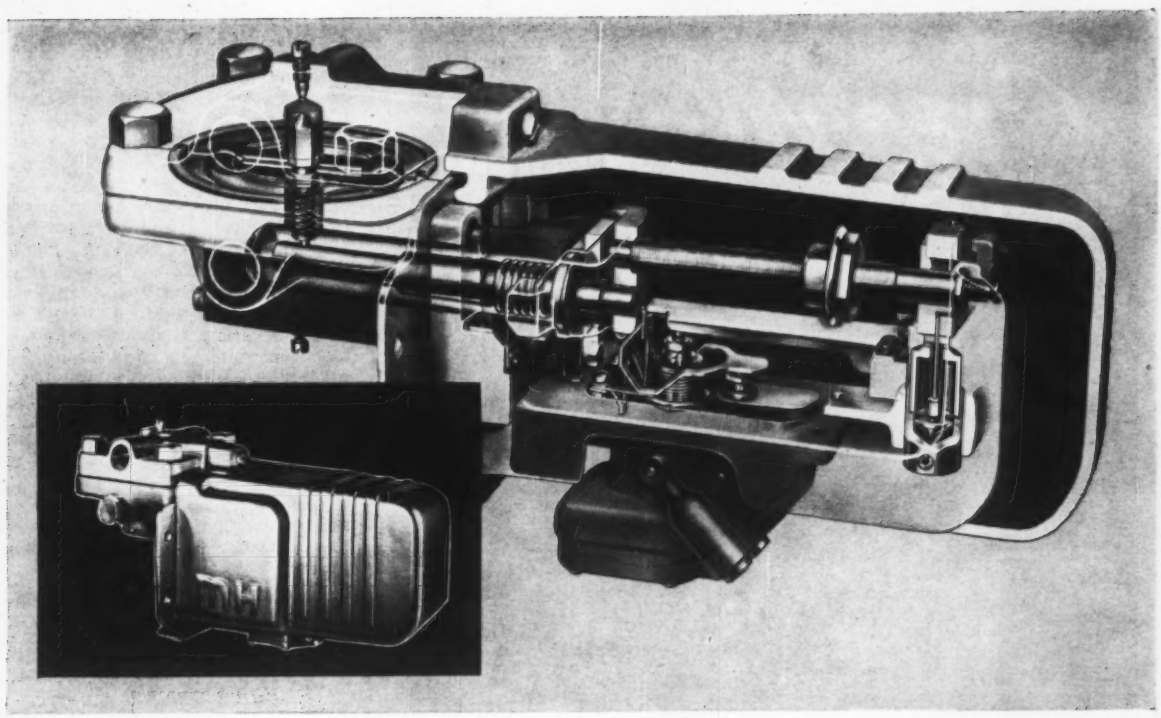
Experimental and Production Blowing
Your Inquiries Invited.

FABRICATED and CUT to Your SPECIFICATIONS

Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contract Cutters of Tube and Rod.

CRYSTAL GLASS TUBE & CYLINDER CO.
7318 South Chicago Ave. • Chicago 19, Ill.

CIRCLE 96 ON READER-SERVICE CARD



Three Honeywell Differential Converter* models give you...

Full-range control of flow and liquid level

1. For measuring gas and water flows: One model has a range of 0-5 to 0-25 inches of water. It can also be adapted to the measurement of specific gravity of liquids in open tanks. Available with *Buna-N* diaphragm.

2. For measuring liquid level in closed tanks: One model has a range of 14 to 50 inches of water, with maximum suppression of 75 inches. Another model, with a range of 50 to 200 inches of water, has maximum suppression of 200 inches. Available with *Teflon*** or *Viton A*** diaphragm.

3. For measuring flow and liquid level in open tanks: Two models with ranges from 0-20 to 0-200 inches of water differential and 0-100 to 0-1000 inches. Available with *Teflon* or *Viton A* diaphragm.

Now, standard models of the *Differential Converter* cover any range from 0-5 to 0-1000 inches of water—the widest choice of ranges we know of. And newly available *Viton A* and *Teflon* diaphragms make the *Differential Converter* ideal for a wide variety of applications. *Teflon* diaphragms are well suited for use with hard-to-handle fluids. *Viton A* has excellent mechanical properties which practically eliminate zero drift.

The *Differential Converter* measures gas and liquid flow or liquid level with accuracy within ±1% . . . and with rapid response, upscale and down. Range is continually adjustable in the field, without parts change, and field calibration is easily checked without weights. Air consumption is extremely low.

Compact and lightweight, these mercuryless transmitters can be mounted anywhere. They're ideal companions for Honeywell *Tel-O-Set** miniature instruments. Call your nearby Honeywell field engineer for full details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Tradename, Minneapolis-Honeywell

**Tradename, E. I. du Pont de Nemours & Co., Inc.

75th YEAR
PIONEERING THE FUTURE

Honeywell
First in Control
SINCE 1885

CIRCLE 97 ON READER-SERVICE CARD

Stearns electro-magnetic

DISC BRAKES

THE CHOICE OF LEADING MOTOR MANUFACTURERS

. . . help step up production 300% with this Kearney & Trecker Special Production Machine Tool

This special "K & T" two-spindle, precision, production machine tool for the electric power industry mills both inside and outside radii of curved, alloy steel turbine blades in a single pass — at three times former conventionally tooled feed rates. A versatile 360° drum fixture handles 81 different blade sizes *without overtravel on rapid stroke for extremely short cycle time* . . . a function of Stearns Brakes on machinery for all industries. "K & T" engineers specified Stearns for this tough, rapid-cycle application due to previous experience . . . the efficiency, longer life, exclusive "Visi-Wear-Indicator," and ease of installation and maintenance — the only brakes where a screwdriver is a complete maintenance tool kit.

For solutions to YOUR brake and clutch problems, call the Stearns Representative in your vicinity. Or write, stating your specific requirements, directly to . . .

BRAKES · STEARNS ELECTRIC · CLUTCHES · MILWAUKEE

Stearns ELECTRIC CORPORATION

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CIRCLE 98 ON READER-SERVICE CARD

FOUR-PORT SELECTOR VALVE

New dual four-port Selector Valve, Model P2-418, is actuated by 90° rotation of the single handle which permits reversal of flow direction of two fluid systems through two alternate systems. It is intended for use with chromatographic or other gas analyzer circuits, as well as with precision test systems requiring simultaneous dual system control. "O"rings, precision fitted into specially machined grooves, eliminate body and cross-port leakage. Limited flow passages and minimum dead volume are other features. Plugging one port in either of the dual valves converts it to three-way operation. Available in either aluminum or Type 303 s.s with ⅛"-NPT connections. Good for air, vacuum, carbon dioxide, helium, hydrogen, nitrogen, oxygen, hydrocarbons, etc.—*Circle Seal Products Co., Inc.*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 227 ON READER-SERVICE CARD

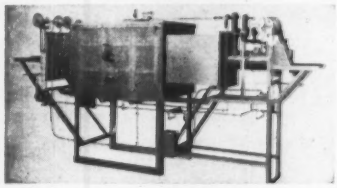
ELECTRONIC STROBOSCOPE

New triple-range Electronic Stroboscope is for speed measurements between 200 and 15,000 rpm. Ranges are 200 to 900 rpm; 900 to 3600 rpm; and 3600 to 15,000 rpm. Neon discharge tube produces sharply-focused red light which can be observed easily in daylight. Maximum flashing frequency is 250 cps. Accuracy to ±0.5%.—*Kernco Instruments, Inc., Box* 1284, *Church St. Sta., New York* 8, *N. Y.*

CIRCLE 228 ON READER-SERVICE CARD

HI-TEMP ELECTRIC FURNACES

New series of compact research and production Furnaces, Type M-Y, which provide uniform heat for applications requiring temperatures to 3300°F, features molybdenum-wound



elements, and can be used with a variety of non-oxidizing, reducing, or inert atmospheres. Ideal for ceramic metallizing, specialty sintering, silicon depositing and diffusing, and for developing new heat-treating techniques in ceramics, electronics, and other close-tolerance, high-temperature applications.—*C. I. Hayes, Inc.*, 894 *Wellington Ave., Cranston* 10, *R. I.*

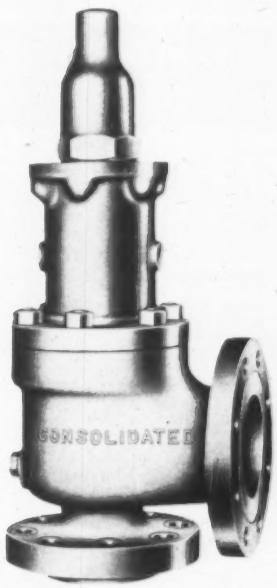
CIRCLE 229 ON READER-SERVICE CARD

FOR MORE INFORMATION ON PRODUCTS REPORTED OR ADVERTISED IN THIS ISSUE, CIRCLE NUMBER ON CARD ON PAGE 705

seal

CONSOLIDATED SAFETY RELIEF VALVE'S Sealing Bellows protects against damage from contaminants, corrosion, or viscous fluids

saves



Consolidated Safety Relief Valves are available in both Balanced Bellows and Standard designs. The Standard type has an eductor tube that effectively removes bonnet pressure.

Balanced Bellows Type Consolidated Safety Relief Valves have a durable, two-ply stainless steel Sealing Bellows that isolates and protects working parts from destructive elements in the lading fluid.

The bellows is balanced with the seating surface. Even with superimposed back pressure in the relieving system, valve performance is consistently stable and dependable. The bellows does not affect the high capacity of the valve, nor does it require change in set pressure. Even the blowdown adjustments are limited.

Additionally, Consolidated Safety Relief Valves now offer a no-leak tightness maintained by a resilient "O" Ring Seat Seal retained in the valve disc. This Seal assures tightness at operating pressures far closer to set pressure than with metal-to-metal seats alone, yet does not carry the seat load imposed by the spring. The Seal also takes piping strains much better than all-metal seating.

The Sealing Bellows and "O" Ring Seat Seal are typical of the extra quality built into Consolidated Safety Relief Valves to assure absolute protection for personnel and plant. These fine features plus flat seating and single ring construction also eliminate many maintenance problems and costs. Write for Catalog 1900 and Bulletin 1940.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

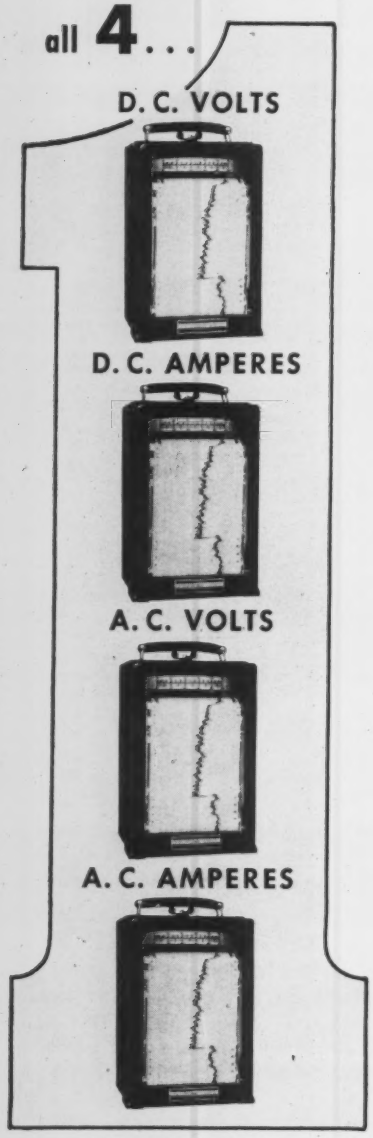
Valve Division • Tulsa, Oklahoma

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 99 ON READER-SERVICE CARD

MORE FOR YOUR MONEY

This 1 Esterline-Angus Multi-Purpose Recorder measures and records all 4...



Also available in various combinations of the above. Write us your requirements or send for Catalog Section 48.

THE
Esterline-Angus
COMPANY

No. 1 in fine Graphic Instruments for more than 50 years.

DEPT. G, BOX 596, INDIANAPOLIS 6, INDIANA

CIRCLE 100 ON READER-SERVICE CARD

ULTRASONIC CLEANERS

New series of Clarco Ultrasonic Cleaners includes models to remove carbon, paint and other contaminations; light soils from all metals; for cleaning and brightening copper; for removing scale, rust and heavy soil; for heavy-duty cleaning of steel parts and magnesium alloys; and for deoxidizing aluminum and aluminum alloys. —*Clarkson Labs., Inc., 930 N. Darien St., Phila. 23, Pa.*

CIRCLE 230 ON READER-SERVICE CARD

TEMPERATURE-PROBE LEADS

New long-length Leads for use with A+ semiconductor instruments for measuring the various temperature layers that form when water, petroleum by-products, liquid chemicals and plastics and other fluids stratify, pinpoint various strata and maintain quality control and uniformity in a given fluid. Completely water- and oil-tight, and abrasion-resistant, they have a probe protected by s.-s. guard. —*Atkins Technical, Inc., 1276 West Third St., Cleveland 13, Ohio.*

CIRCLE 231 ON READER-SERVICE CARD

MAGNETIC AMPLIFIER

New Model 1201 low-level Signal Amplifier incorporates an adjustable network to adapt it to a range of sensor voltages (from 0-1 mv to 0-500 mv) and impedances. For all sensors the output of the amplifier is 0-5.0 vdc. Powered from 28 vdc ±5%. Characteristics of amplifier include—output signal: (for all types of sensors indicated) 0-5.0 v; output linearity: ±1% of full scale (50 mv); output ripple: 50 mv rms max; frequency response: approx. 2 cps.—*Lumen, Inc., Moen Ave., Box 905, Joliet, Ill.*

CIRCLE 232 ON READER-SERVICE CARD

Outstanding Accuracy

PALMER

Dial Thermometer

Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

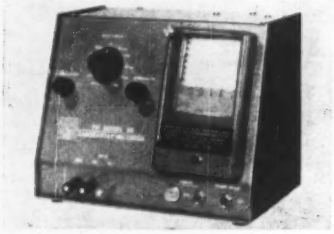
PALMER
THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers
2515 Norwood Ave., Cincinnati 12, O.

CIRCLE 101 ON READER-SERVICE CARD

LABORATORY RECORDER

New Model 80 Laboratory Recorder which has 5 full-scale calibrated voltage ranges, (10 and 100 mv; 1, 10, and 100 v) and 5 full-scale calibrated current ranges (1, 10, and 100 μa; 1 and 10 ma) can be operated as a zero-left, zero-center, or zero-right recorder and provides 4 times full chart width expansion on all ranges. Mechanical features include window for chart notation during operation,

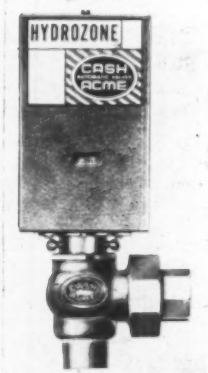


built-in chart take-up, and a means for obtaining tear-off records for short run observations. The Model 80 comes equipped and 1"/hr and 15"/hr operation. Basic operation principle is that of a galvonometer with a chopper bar pointer clamped briefly for marking every two seconds. The chopper d-c amplifier used is stabilized with negative feedback. Bulletin gives details.—*Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio.*

CIRCLE 233 ON READER-SERVICE CARD

ZONE CONTROL VALVE

New Hydrozone, a motorized Zone Control Valve for hydronic heating and cooling systems, and for steam up to 10 psig, features a visual valve in-

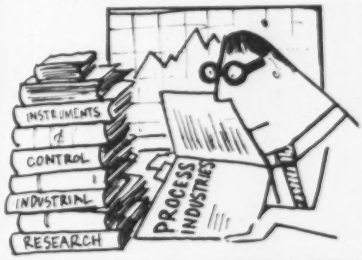


dicator, which makes it easy to set for manual operation in case of power failure. "O" ring avoids leakage at valve stem. Valve has 100% shut-off feature. Available in ¾", 1" and 1¼" sizes. Bulletin I-Z-I contains details. —*Cash-Acme, Box* 191, *Decatur, Ill.*

CIRCLE 234 ON READER-SERVICE CARD

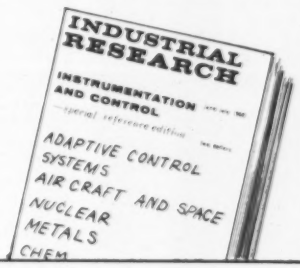
The nation's leading instrumentation authorities are busy writing a special Reference Book *on all that's new in instrumentation & control for*

. . . the man who uses instrumentation & control devices (how the major industries can; will, and should *profit from them).*



. . . the producer of instrumentation & control devices (what industry wants from him—and how he can answer its problems).

This thick, $2 reference volume will be published as the June-July issue of Industrial Research *magazine. It's a* must *for everyone interested in this fast-moving field.*



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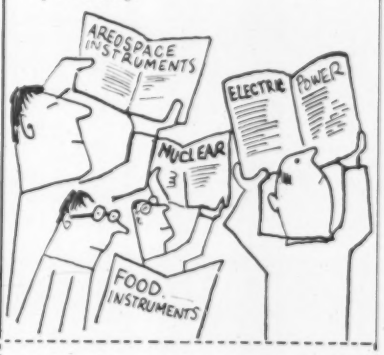
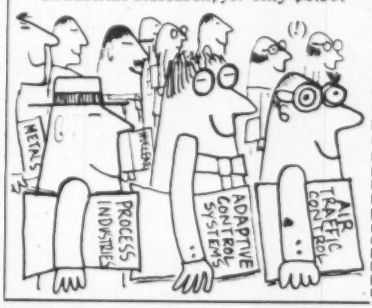


But most *of them took advantage of a special offer and got the $2 edition, plus a $5, one-year subscription to* Industrial Research, *for* only *$2.50.*



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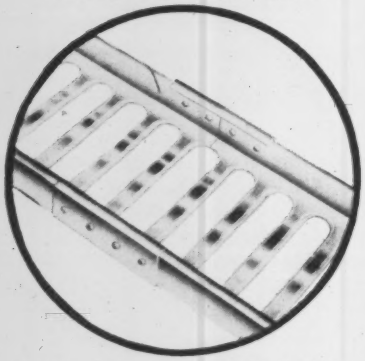

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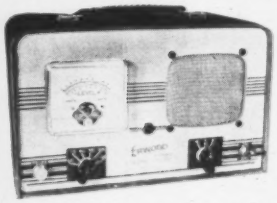
CIRCLE 103 ON READER-SERVICE CARD

ELECTRO PROBE

New Model 101B Electric Probe detects, locates, and measures noise and vibration in machines and mechanical

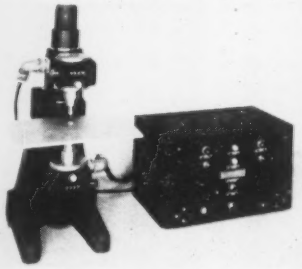


systems. Useful in non-ferrous grinding and burnishing machines to detect the point of contact of the grinding wheel or burnishing tool, in the automotive industry, for portable electric tools, home appliances, etc.—*Erwood Inc.*, 1770 *W. Berteau, Chicago* 13, *Ill.*

CIRCLE 235 ON READER-SERVICE CARD

ELECTRONIC MICROMETER

New Model VDR Carson-Dice Electronic Micrometers is said to be the first opposed-head measuring device permitting pressureless measurement from two sides to the centerline of a

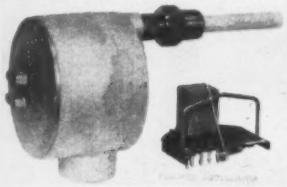


fragile or compressible part. Electronic controls bring upper tip downward to touch top of part, lower tip upward through hole in lower anvil to contact bottom. Measurements to 20 millionths of an inch are automatically displayed on easily read counters.—*J. W. Dice Co., Englewood, N. J.*

CIRCLE 236 ON READER-SERVICE CARD

TRANSISTOR LEVEL CONTROL

New transistorized Model B-07 Electr-O-Probe Level Control for liquids, granular solids, and liquid/liquid



interfaces features a solid-state circuit design, unitized, explosion-proof construction, and choice of failsafe or direct action. Descriptive Price Sheet contains details.—*Instruments, Inc., Box* 556, *Tulsa, Okla.*

CIRCLE 237 ON READER-SERVICE CARD

YOU CAN DEPEND UPON **PM**

ACCURATE DIGITAL TORQUE INDICATOR

Just ONE model from PM's family of null-balance servo type instruments

Gives direct readout of torque from rotary shaft torque pickups

PM's Digital Torque Indicator (DTI-2) is widely used in industrial and laboratory applications where high accuracy (0.1% full scale) and high reliability are essential. Its many features include a self-contained filter that integrates torque pulsations encountered in most systems. Digital readout provides a long effective scale length (resolution 1 part per 4000) and readings free from parallax. This instrument is complete in every way, even including its own strain gage power supply.

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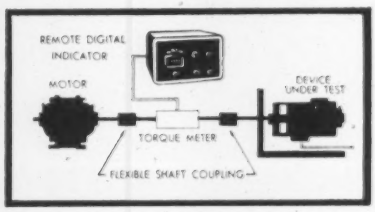

Torque readings are simplified with a strain gage torque pickup and PM's Indicator. Note how shaft torque is measured directly with no inertial losses as may be encountered in dynamometer trunnion bearings. Torque pickups may be installed in several points of a drive train to measure progressive losses.

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CIRCLE 104 ON READER-SERVICE CARD

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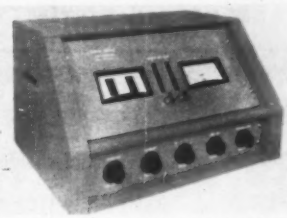
CIRCLE 105 ON READER-SERVICE CARD

CARBON DIOXIDE MONITOR

New Model TBA Gas Analyzer, a Gas Stream Monitor for continuous indication and control of CO_2 concentrations under 2% in nitrogen gas



streams, uses a thermal-conductivity sensing detector with the sensing cell immersed in a temperature controlled oil bath and bridge current controlled precisely by means of a transistor regulated power supply. The equipment is accurate to better than ±0.05% CO_2.—*Industrial Instruments Engineering Corp., 89 Commerce Rd., Cedar Grove, Essex County, N. J.*

CIRCLE 238 ON READER-SERVICE CARD

PORTABLE pH METER

New portable Model 700 Big Scale pH Meter reads values within 0.02

pH. Line operated, it features a single operating control and a high-output electronically-modulated amplifier with printed circuitry.—*Analytical Measurements, Inc., 585 Main St., Chatham, N. J.*

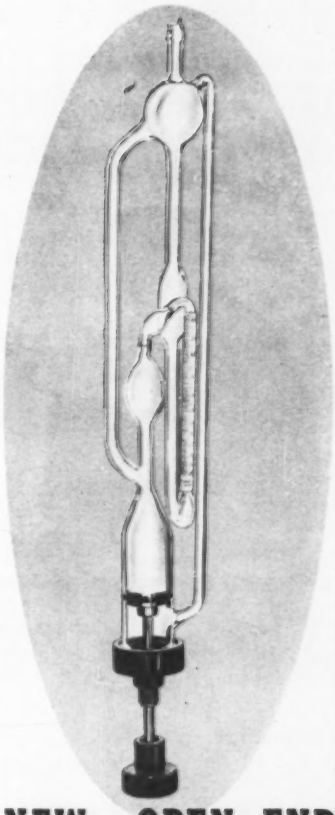
CIRCLE 239 ON READER-SERVICE CARD

ABS PRESSURE TRANSDUCER

New sub-miniature Absolute Pressure Transducer, Model 720, utilizes a new concept in Bourdon-tube design whose displacement is transmitted di-

rectly to the moving contact of a precision-wirewound potentiometer producing a high-level a-c or d-c output proportional to the input pressure. No mechanical linkages, bearings, or multiplications are used. Static error band (includes linearity, friction, hysteresis, resolution, and repeatability) is as low as ±1.0%. Details in Bulletin 720/A/O.—*Bourns, Inc., Box 2112, Riverside, Calif.*

CIRCLE 240 ON READER-SERVICE CARD



NEW...OPEN END McLEOD GAUGE

COMPRESSES GAS BETWEEN TWO MERCURY COLUMNS...

ELIMINATES CAPILLARY CONTAMINATION...

GIVES EASY, ACCURATE READING!

Two Scales 0-10mm. and 1-1000 micron Micrometric Adjustment of Mercury Meniscus!

Most simplified and accurate McLeod Gauge yet devised! No closed end capillary to become contaminated... no needlessly complicating comparison capillary... no more compounding of error in measuring—*one* direct reading manometer replaces former 2 tubes! Rubber "O" ring vacuum sealed piston operating in precision bore tube allows micrometric adjustment of mercury meniscus. You get most rapid, most accurate readings ever!

VG1100 VACUUM GAUGE, OPEN END McLEOD TYPE, 18" long, ready for use but without mercury. 69.50

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CIRCLE 106 ON READER-SERVICE CARD

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DIRECT INK OR ELECTRIC RECTILINEAR RECORDING SYSTEM

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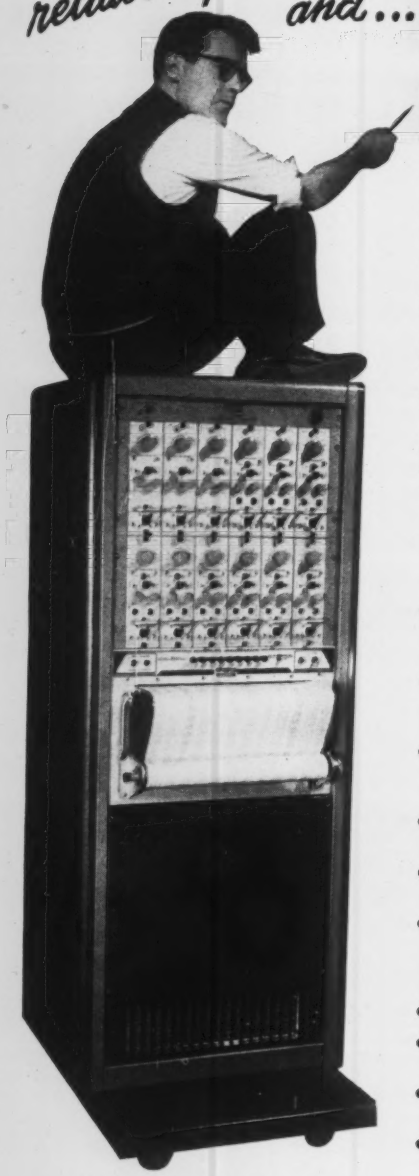

This new Recording System, Model BSA-1200, combines all the advantages of rectilinear recording with the economy of ink writing in ⅓ less space than any comparable system. At an average chart speed of 50 mm/sec., for example, you save $10,000 every 200 hours in chart costs alone when compared to other rectilinear recording systems. In addition, this system is designed to accept a wide choice of different interchangeable plug-in preamplifiers for each of the 12 recording channels.

ADDITIONAL FEATURES

- **High Speed Rectilinear Recording with *Ink*. Unique pen design provides splatterproof writing to 200 cycles.**
- **Wide Frequency Range reproduces signals from DC to 200 cps on rectangular coordinate chart paper**
- **Interchangeable Plug-in Preamplifiers — Low, Medium, High Gain DC, AC, Chopper, Carrier, and Servo**
- **Automatic one second timer and manual EVENT MARKER**
- **18 Speeds — Push-button Controls (Remote control optional)**
- **Individual Power Supplies and Transistorized Driver Amplifiers for each channel. Prevents cross-talk between channels**
- **Pen Motor Overload protection**
- **Interchangeable pens for either Ink or Electric Writing**
- **Micrometer Pen Motor Adjustments for accurate pen alignment**
- **Plug-in provisions for remote or centralized control of all functions**
- **Modular Design throughout for ease of servicing**

Write for complete information on High Speed Recording Systems

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ELECTRONICS INC

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HINGHAM, MASSACHUSETTS

CIRCLE 107 ON READER-SERVICE CARD

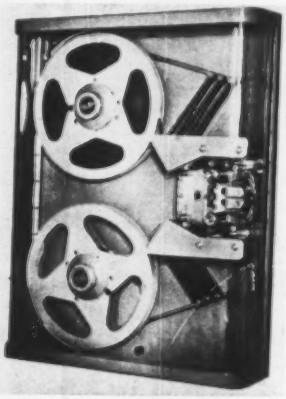
MULTI-PURPOSE PRESSURE GAGE

New 4½" Gearcoid Gage Type 110, a heavy-duty, geared-movement pressure gage, has integrally designed socket, tube, tip, movement, pointer, and dial assembly which permits installation by hand-turning the gage case. Features include heavy-duty drawn steel case, bronze-bushed pinion and segment shafts, nickel silver pinions, s.-s. hairsprings, precision geared movements and grade "A" phosphor-bronze Bourdon tubes with silver-brazed joints. Bulletin DH-333 gives details.—*Helicoid Gage Div., American Chain & Cable Co., Inc., 929 Connecticut Ave., Bridgeport 2, Conn.*

CIRCLE 241 ON READER-SERVICE CARD

MAGNETIC TAPE TRANSPORT

New 906 (Mark II) Magnetic Tape Transport features 400,000 character/sec transfer rate achieved with complete program freedom at 120"/sec with 10½" reels of 1"-wide tape and 16 channels of the Potter High Density Recording System. New transport design includes a redundant guide system and an improved braking mechanism, both contributing to minimum tape wear. A non-adjustable, fully-interchangeable head mounting assures precise tape alignment at all times. Solid-state electronics supported by logically arranged plug-in boards provide the servo drive and control.—*Potter Instrument Co., Inc., Plainview, L. I., N. Y.*



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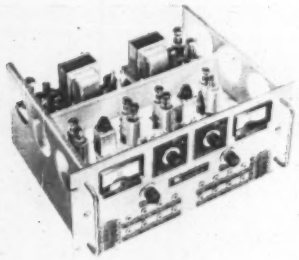
SERVO CONTROLLER COMBINATIONS

New high-performance electronic Servo-Controller Combinations, Series 800, can fully reproduce the transfer functions described by a typical high-grade analog computer. Each unit, comprising a controller, servo-amplifier, and power supply, is capable of



performing any of the three basic control functions: summation, integration, and derivative. The combinations can be applied to the control of any electrically-measurable variable. They are primarily used with electro-hydraulic actuators, but also with electrical and pneumatic actuators.—*CompuDyne Corp., Products Div., 780 South Warminster Rd., Hatboro, Pa.*

CIRCLE 243 ON READER-SERVICE CARD

DIFFERENTIAL PHOTOMETER

New Model 210 Photometer measures the intensity difference between two light sources or can measure and record the intensities of the two light

sources independently. Using a 50-amp/lumen photomultiplier tube, each scale division can represent as little as 2 $\mu\mu$lumens. Other features include a continuous, easily resettable 10:1 sensitivity adjustment for each channel and individually-adjustable high-voltage outputs. Bulletin D-210 gives details.—*Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif.*

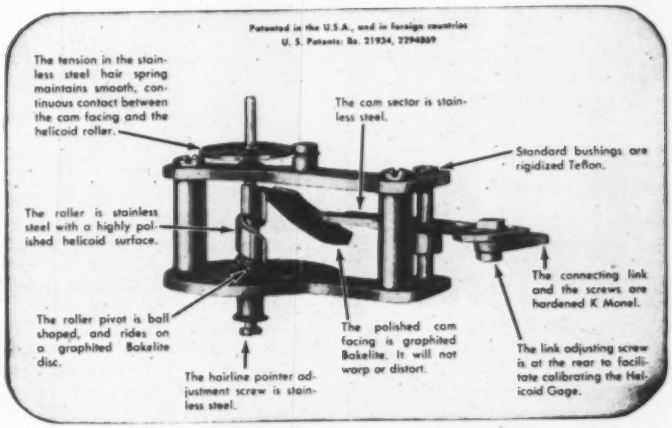
CIRCLE 244 ON READER-SERVICE CARD

STRAIN GAGE ADAPTER

New SGA-100B Strain Gage Adapter includes all necessary circuitry for the read-out of any strain-gage-type flow-, pressure-, weight-, or force-transducer on self-balancing d-c millivolt potentiometers or recording oscillographs of suitable sensitivity. A zener-regulated bridge supply is used with the excitation adjustable between 2.5 and 10 less vdc nominal. Output is 0-10 to 0-30 mvdc.—*Ramapo Instrument Co., Inc., 8 First St., Bloomingdale, N. J.*

CIRCLE 245 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy*... on the toughest jobs

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

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Helicoid Gage Division • American Chain & Cable Company, Inc.

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CIRCLE 108 ON READER-SERVICE CARD

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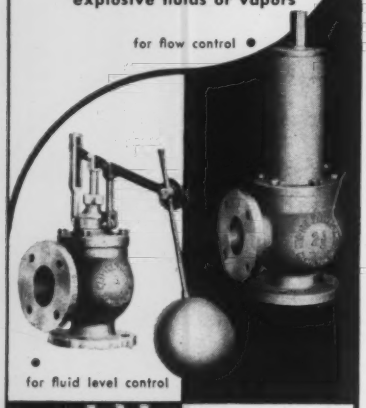

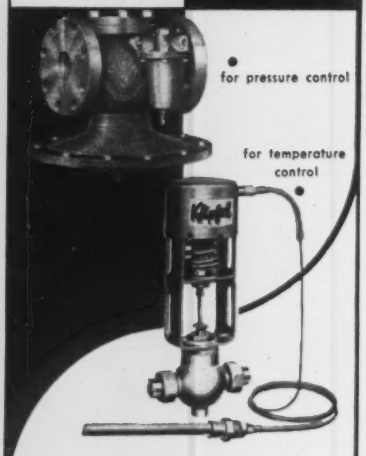

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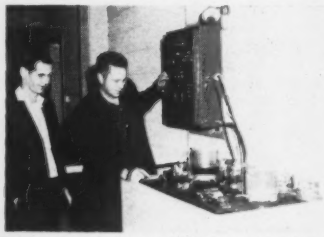
HAMILTON, OHIO
A DIVISION OF THE HAMILTON-THOMAS CORPORATION

CIRCLE 109 ON READER-SERVICE CARD

RESTARTING CONTROL

New Model TR-9250 Restarting Control permits electric motor-powered equipment to resume automatic operation after a power failure without the aid of manual restarting.

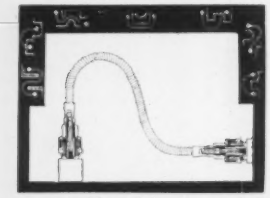


This standard control component provides also for positive shutdown in the event of high or low pressures, temperatures, and levels. The control operates with a relay circuit which permits line pressures, temperatures, or levels to return to normal condition after a power failure restart.—*Frank W. Murphy, Mfr., Inc., Tulsa* 1, *Okla.*

CIRCLE 246 ON READER-SERVICE CARD

FLEXIBLE SHAFT ASSEMBLIES

New Circle Ess Standard Flexible Shaft Assemblies are made in 180 variations which provide the same



advantages offered by a special flexible shaft assembly plus many additional advantages. Assembled from stock components, they offer economy of both time and expense. Illustrated catalog contains details.—*F. W. Stewart Corp.,* 4311-13 *Ravenswood Ave., Chicago* 13, *Ill.*

CIRCLE 247 ON READER-SERVICE CARD

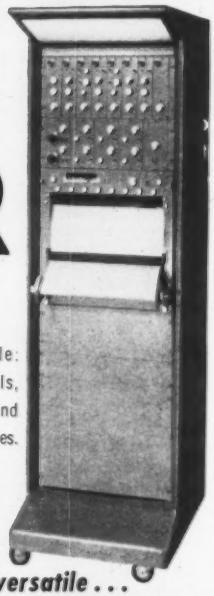
HYPER ENVIRONMENTAL TEST FACILITY

New hyper environmental Test Facility produces at least 1200°F of radiant heat under altitude conditions of at least 500,000 ft or 1 x 10^{-6} mm Hg abs. This is said to be one of the highest altitudes ever simulated in combination with such extreme heat. Other unusual features of the chamber are a vapor trap operating in the range of −120°F, and an automatic hot gas defrost. Vapor freezing insures more efficient operation of the vacuum pump, while the defrost mechanism takes care of frost collecting on the coils. Exterior dimensions, including machinery and instrumentation, are approx. 4′ x 8′ x 7′ high. Inside work space is a cylinder 30″ dia x 30″ deep.—*Tenney Engineering, Inc., Union, N. J.*

CIRCLE 248 ON READER-SERVICE CARD

THE OFFNER
ALL TRANSISTOR DYNOGRAPH

TYPE **R**



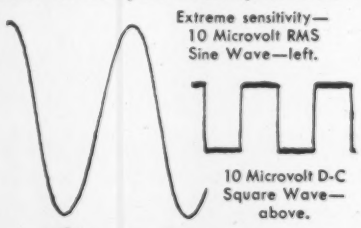
Models available: 1 to 19 channels, console, rack, and portable assemblies.

the most versatile . . . most sensitive direct-writing recorder available

Whatever your application for direct-writing oscillograph recording . . . investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Its features of superiority are *unmatched!*

- ✓ **High Sensitivity: 1 microvolt d-c per mm**
- ✓ **High Frequency Response: 0-150 cps— ± 10%**
- ✓ **Large Linear Deflection: over 6 cm—½% linearity**
- ✓ **Wide Ambient Range: —20° C to + 50° C**
- ✓ **Versatile: d-c, a-c, carrier, all with one set of amplifiers**
- ✓ **Convenient: Plug-in input couplers for all bridge balancing**
- ✓ **Stable: Drift—1 microvolt per hour at maximum sensitivity**
- ✓ **Recording Media readily interchangeable: Heat, Electric, Ink; Rectilinear, Curvilinear**
- ✓ **Compact: Eight channels in only 35″ of rack space.**

Write for full specs and complete details



OFFNER ELECTRONICS

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

CIRCLE 110 ON READER-SERVICE CARD

SCAM®

DE-LINE

THE ENGINEER'S

ANNUNCIATOR

GREATEST FLEXIBILITY IN THE FIELD

AVAILABLE IN MANY SEQUENCES

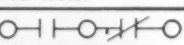
BACKLIGHTED

OR

BULL'S-EYE

SIDE BY SIDE OR STACKED, DE-LINE modular design retains original custom appearance as system grows.

SAME PLUG-IN operates from normally open OR normally closed trouble contacts.



AUXILIARY CONTACTS N.O.-N.C. standard with most plug-ins.

SEQUENCE OPTION after installation by means of independent slide switch at each point.

DE-LINE plug-ins are self-policing. Systems are rugged and dependable.

THE SCAM INSTRUMENT CORP.

Dept. G, 1811 W. Irving Park Rd. • Chicago 13, Ill.
GRaceland 7-7850

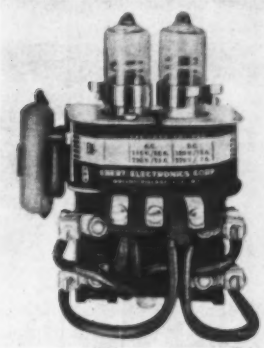
REPRESENTATIVES IN ALL PRINCIPAL CITIES

COMPLETE MONITORING SYSTEMS FOR INDUSTRY

CIRCLE 111 ON READER-SERVICE CARD

POWER RELAY

New EM-84 Sensitive Power Relay requires currents as low as 0.019 amp through an external contact (thermometer, contact-meter, probes, etc.)

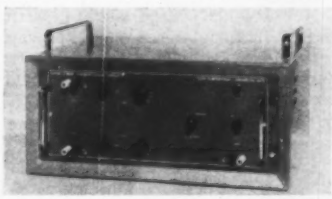


to operate the unit which employs an energizing coil in a resonant circuit. It employs liquid mercury-to mercury contacts for silent, maintenance-free operation, and is hermetically sealed in an inert gas atmosphere.—*Ebert Electronics Corp.*, 212-26 *Jamaica Ave., Queens Village* 28, *N. Y.*

CIRCLE 249 ON READER-SERVICE CARD

RANDOM SIGNAL CORRELATOR

New Model 13A1 Random Signal Correlator can be used to measure the normalized cross correlation between any two signals, either random or periodic. Frequency range is between 2 cps and 250 kc, and accuracy



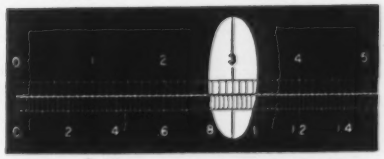
is 1%. It provides two identical amplifier channels with independent adjustable gains. The output selector circuit permits selection of either of the two channels or of the correlated signal. After the two channels have been equalized, positive or negative correlation can be read out directly on a true-rms voltmeter. Input voltage range is 20 mv to 2 v rms and gain is continuously variable from 1 to 100 in each channel. —*Flow Corp.*, 85 *Mystic St., Arlington, Mass.*

CIRCLE 250 ON READER-SERVICE CARD

THERMOWELL PACKAGING

New system of Thermowell Packaging to facilitate in-plant stocking by maintenance departments consists of individual cartons incorporating complete identification listings of the packaged well. The package has been designed to facilitate shelf storage, while providing maximum protection for the thermowell.—*Trinity Equipment Corp., Cortland, N. Y.*

CIRCLE 251 ON READER-SERVICE CARD



METERS THAT TAKE

125,000,000% OVERLOAD!

Because of the **revolutionary** bifilar frictionless (no pivot) movement, plus weightless light-beam pointer, GREIBACH PRECISION METERS withstand 100,000% overload surges. Then, for **extraordinary** overload risk applications, a special built-in Protective Circuit takes up to 125,000,000% overload surges **without impairment.**

FRICTIONLESS BIFILAR SUSPENSION MOVEMENT

Only GREIBACH offers such overload immunity, along with: Sensitivity down to 0.2 microampere full scale. Accuracy better than ¼ of 1%. Energy dissipation as low as 4×10^{-10} watt. Permanent reliability. Mechanical ruggedness withstanding up to 500 G's shock.

GREIBACH PRECISION METERS are available in portable, bench and panel models with wide selection of ranges, even up to 23 ranges in one meter: e.g., .2 / .5 / 1 / 2 / 5 / 10 / 20 / 50 / 100 / 200 / 500μA / 1 / 2 / 5 / 10 / 20 / 50 / 100 / 200 / 500MA / 1 / 2 / 5-AMP.

Verify these extraordinary advantages by seeing actual demonstrations arranged upon request.

MODEL #700

NO PARALLAX FROM ANY ANGLE.

Full 6" flat scale. External light-beam power source.

5⅜" h x 8$\frac{5}{16}$" w x 11¾" d

Ask for Literature...

Technical details as well as complete specifications sent on request.

GREIBACH INSTRUMENTS CORPORATION

215 North Avenue, New Rochelle, New York

CIRCLE 112 ON READER-SERVICE CARD

NEW
DC driven
CHOPPERS

No AC!

For battery-operated portable low-level d-c amplifiers
and
For transistorized d-c amplifiers. Removes stray a-c signals from chassis wiring. Eliminates null offsets.

Write for Catalog 554

STEVENS
INCORPORATED
ARNOLD

7 ELKINS STREET
SOUTH BOSTON 27, MASS.

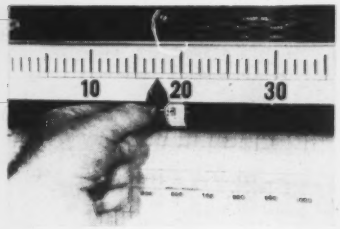
S/A 21-1/3 V

CIRCLE 113 ON READER-SERVICE CARD

NEW INSTRUMENTS

MULTIPOINT RECORDER

New Multipoint Strip Chart Recorder, Universal Model 15 ElectroniK, is for application in laboratories

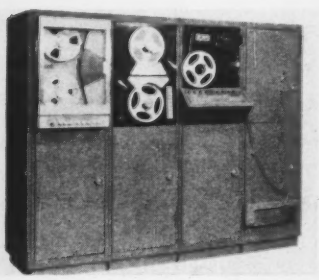


and in industrial processes where frequent record changing is required, or where it may be desirable to change the type of primary element, or range or measurement. Switching from 2 to 3, 4, 6, 8, 10, 12, 16, 20 or 24 points is done by simply changing a shorting plug and appropriate indicating and prints wheels. Models are equipped for potentiometer or resistance thermometer circuits and have zener diode-regulated constant voltage units.—*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne & Windrim Aves., Phila. 44, Pa.*

CIRCLE 252 ON READER-SERVICE CARD

BI-DIRECTIONAL TAPE CONVERTER

New Dykor Model D104 bi-directional fully-transistorized Tape Converter converts information directly from punched paper tape (produced by teletype transceivers) to magnetic tape in any parallel 7-bit alpha-numeric



code, or data on magnetic tape (produced by a computer) to their corresponding form on teletype paper tape. Paper-tape data are introduced by a photoelectric reader operating at 300 characters/sec. Magnetic tape is read or prepared in a form completely compatible with the computer it is to feed. Paper-tape output is prepared by a high-speed perforator punching at a rate of 2400 words/min in standard teletype five-level code.—*Dykor Systems Div., Digitronics Corp., Albertson, L. I., N. Y.*

CIRCLE 253 ON READER-SERVICE CARD

MERCOID®

LOW PRESSURE CONTROL

FOR AIR OR GASES

New low pressure diaphragm control for gases or air. Can be used three ways; for pressure, negative (vac.) pressure or differential pressure.

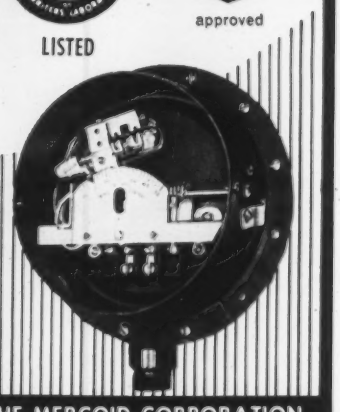
Two operating ranges, 1.0" to 30.0" and 1/2 to 5 psig.

External Adjustment
Sealed mercury contact
Visible calibrated dial
Visible on-off circuit
Repetitive trip point

WRITE FOR BULLETIN PG

UL LISTED

FM approved

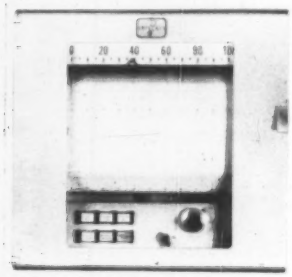


THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

CIRCLE 114 ON READER-SERVICE CARD

SELECTOR RECORDER

New Selectomatic Dynamaster provides optional recording of any or all of 24 points. Selector system makes it possible to record desired variables with no time lost for recording unwanted measurements. Simply setting

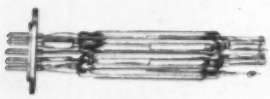


a two-position (on-off) pin for each point determines the program of variables measured. Attachments offered include manual scanning and printing, a multi-speed chart-drive, a two-speed chart-drive, and span and/or zero adjustment.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 254 ON READER-SERVICE CARD

HIGH-SPEED RELAY

New Clareed sealed-contact Reed Relay with magnetically-operated contacts enclosed in an inert atmosphere inside a hermetically-sealed glass



capsule, is ideally suited for transistor drive applications as well as computers, data processing, and automation equipment. Having nickel-iron alloy reeds gold-plated at the contact surfaces, the switch can operate in 0.8 msec and it can release in 0.25 msec. Withstands 40 G's shock. Spec Sheet gives details.—*C. P. Clare & Co.*, 3101 *Pratt Blvd., Chicago* 45, *Ill.*

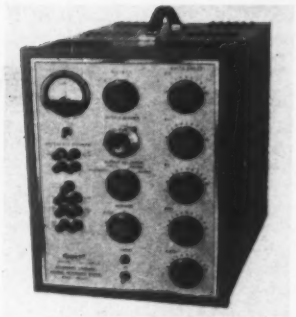
CIRCLE 255 ON READER-SERVICE CARD

REFLECTANCE AND EMISSIVITY SPECTROPHOTOMETER

New Model 205 Spectrophotometer is a recording instrument for reflectivity and emissivity investigations of solid samples such as metals, ceramics, crystals, plastics, paints, and powders. Either total or diffuse reflectivity can be measured with the instrument at temperatures ranging from 400 to 1100°C and at an accuracy of 1%. With a separate heated sample holder emission measurements over the same temperature range can be made. Particularly useful in the area of missile skin and nose cone materials. Details in "Instrument News" Vol. 10, No. 4. —*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 256 ON READER-SERVICE CARD

VOLTAGE REFERENCE SOURCE



New line of secondary-standard Precision Voltage Reference Sources features front-panel null meters and provides 0.01% absolute accuracy with great stability through the use of certified cells and oil-immersed precision resistors. As voltage references, they provide constant fixed voltages of +100.00 vdc. As voltage dividers, the instruments provide directly any percentage of a d-c or a low-frequency a-c external reference voltage with 0.01% accuracy.—*Epsco, Inc., Equipment Div.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

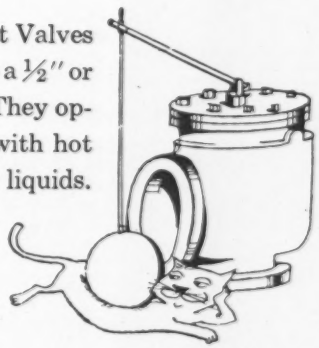
CIRCLE 257 ON READER-SERVICE CARD

LIQUID LEVEL CONTROL

G-A *Cushioned* Float Valve

Sensitive Golden-Anderson Float Valves automatically hold water level to a ½" or 1" variation in tanks, bins, etc. They operate at high or low pressure—with hot or cold water—and most other liquids.

Bulletin W-5A has all the facts.

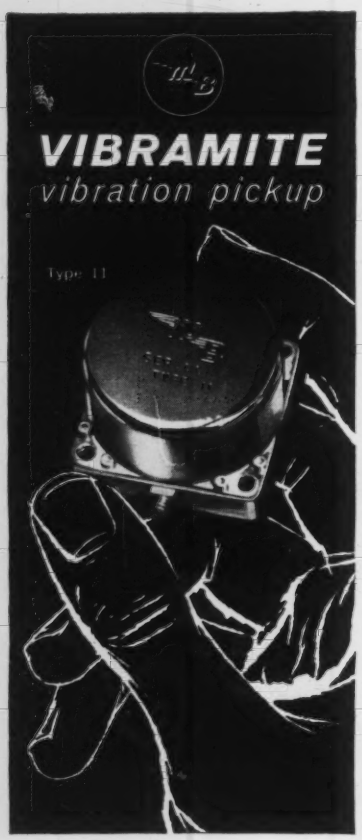


GOLDEN ANDERSON Valve Specialty Company

1286 RIDGE AVENUE, PITTSBURGH 33, PA.

Designers and Manufacturers of VALVES FOR AUTOMATION

CIRCLE 115 ON READER-SERVICE CARD



sensitive...
yet rugged
damped...*yet with*
flat response

In fact, the new Vibramite pickup is the only available damped unit with a flat response curve over its entire operating range.

It is also small in size, light in weight... and can be mounted in any desired position without adjustment.

Check these specifications:

Frequency range	20-2000 cps
Sensitivity	96.3 mv/in/sec. (Calibrated ±1% at 100 cps into 2 megohm load at 80°F)
Size	1" x 1.42"
Weight	2.75 oz
Natural frequency	15 cps
Damping	Eddy current (nominal .65 of critical)
Acceleration output limit	50 g maximum (minimum limited only by recording equipment)
Max. shock without damage	1000 g

Complete technical details in Bulletin 112A. Write . . .

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1103 State Street, New Haven 11, Conn.

CIRCLE 116 ON READER-SERVICE CARD

RATE GENERATOR

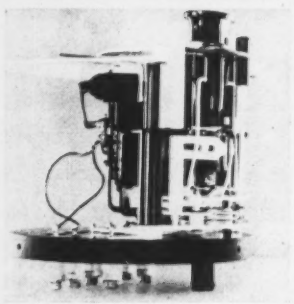
New Model 8601 Photoelectric Pulse Generator can be used either as a rate generator or as an angle-measuring unit. When used as a rate generator, the output frequency is read in terms

of shaft speed. When used to measure angles, the total angle is determined by totalizing individual pulses. The pulses are generated by a light which passes to a photoresistive or photovoltaic cell through rotating.—*W. & L. E. Gurley, Industrial Div., Troy, N. Y.*

CIRCLE 258 ON READER-SERVICE CARD

MEASURING CONTROLLER

New Pantam Measuring-Controller incorporates a photoelectric switching assembly in the same case with a precision electrical measuring instrument, the combination of which makes possible a very versatile and flexible control system. Measuring in-



strument is available with moving coil or electro-dynamic wattmeter; controller consists of two markers. Attached to each marker is a photo resistance. A beam of light moves with the measuring pointer, and when the measuring pointer is lined up with a control marker, the beam of light enters the photo resistance window and activates a relay outside the instrument.—*National Electronics, Box* 1237, *Sheridan, Wyo.*

CIRCLE 259 ON READER-SERVICE CARD

LOENCO
CHROMAT-O-FLEX

WHATEVER YOUR GAS CHROMATOGRAPHY ANALYSIS IS... LIGHT GASES, HIGH TEMPERATURES, WIDE BOILING RANGES... LOENCO HAS INSTRUMENTS SUITED FOR YOUR APPLICATIONS

ACCURATE HIGH-SPEED CHROMATOGRAPH ANALYSIS
over a wide temperature range

NEW, COMPACT LOENCO MODEL 15 gas chromatograph provides the widest range of analyses at very modest cost. Instruments may be operated singly or connected in series operating at different temperature levels for best combination of separation and speed. A combination of features most satisfactory for your needs will be suggested.

model 15 features:

- Measures 13¼ x 12". Wt. 40 lbs.
- Temperature range—from Ambient to 300 degrees C. At small extra cost to 350 degrees C.
- High sensitivity, shielded element detector. Choice of 2 element thermistor detector, or 2 or 4 element filament detector.
- Bubble meter assembly.
- Precise electronic temperature control, proportional type.
- Reproducible volume gas sample valve. (May also be used for trap-out, pre-separator or pre-concentration.)
- Column reverse valve.
- Preparation scale column for separating large samples.
- Hot sample outlet fitting for sample collection.
- Ample oven space for long columns, easy access to column connections.
- Two column series system.

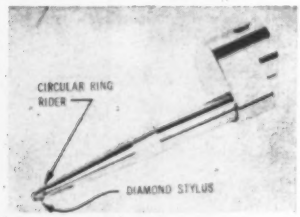
NOW SPEED UP ANALYSES WITH A LOENCO CHROMAT-O-FLEX
For Full Details, Contact

LOENCO
LOE ENGINEERING CO.
237 North Fair Oaks Ave. • Pasadena, California

CIRCLE 117 ON READER-SERVICE CARD

SURFACE FINISH ADAPTERS

New models of small-bore adapters for the Surfindicator (measuring surface finish) include Model BL-113 (see illustration) for use with Brush



motor drive Model BL-117 and a hand-held adapter, Model BL-134. The former permits measurements on limited-access areas such as gear teeth, slots and lands. The latter is recommended for small bores, gear teeth, and slots where hand-held operation is necessitated by location of the surface to be measured.—*Brush Instruments, Div. of Clevite Corp., 37th & Perkins Ave., Cleveland* 14, *Ohio.*

CIRCLE 260 ON READER-SERVICE CARD

DIAL THERMOMETERS

New Bi-Metal Dial Thermometers feature accuracy of 1% of range, a precisely calibrated bi-metal element, a specially designed anti-parallax

scale, plus all-stainless-steel construction and welded joints. External adjustment of pointer is provided through a set screw on a hex nut. Sizes: 3" and 5" dials, both straight and angle forms. Ranges: from —40 /120°F to 200/1000°F.—*Weksler Instruments Corp.,* 195 *East Merrick Rd., Freeport, L. I., N. Y.*

CIRCLE 261 ON READER-SERVICE CARD

THERMAL CONDUCTIVITY CELL

New miniaturized T/C Cell for capillary column gas chromatography is predictable for intermediate sensitivity applications (i.e., 0.01 to 100 weight % in the injected sample). Sensitivity is said to be about 500 x more than that of conventional T/C cells on prototype packing, column diameters and apparatus design. Sample size is 0.001 to 0.005 cc in 2-15 cc/min carrier flow.—*Gow-Mac Instrument Co.,* 100 *Kings Rd., Madison, N. J.*

CIRCLE 262 ON READER-SERVICE CARD

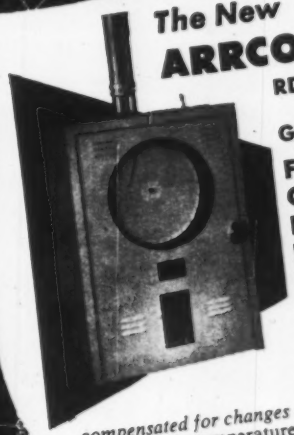
A-C VTVM KIT

New Knight-Kit AC ATVM Kit, Stock No. 83 YX 608, features printed circuitry and a unique, motor-driven automatic range selector. A-c volt ranges are 0.003, 0.010, 0.030, 0.1, 0.3, 1, 3, 10, 30, 100, and 300; decibels, —62 to +52 in 11 ranges. Employing a stable, built-in, 3-stage amplifier, it has ±1 db response from 2 cps to 2.5 mc, and an absolutely flat response from 50 cps to 500 kc.— *Allied Radio Corp.,* 100 *N. Western Ave., Chicago* 80, *Ill.*

CIRCLE 263 ON READER-SERVICE CARD

ARRCO

The New
ARRCO-ANUBIS
RD-B (Dry-Air)
GAS
GRAVITOMETER



FULLY COMPENSATES FOR BAROMETRIC PRESSURE CHANGES

With the new ARRCO-Anubis RD-B Gas Gravitometer you get a highly accurate record of the specific gravity of gases... *fully compensated for changes in barometric pressure* as well as changes in temperature and humidity. It employs two columns; one for gas, one for "dry air." The difference in weight between the "dry air" and the gas in these two columns is measured and recorded in terms of specific gravity. A floating lever attached to the unit of a 6" aneroid barometer assures that the recorded gravity will always be corrected for barometric pressure changes.

ARRCO-ANUBIS GAS GRAVITOMETERS
★ For Recording
★ For Transmitting
★ For Controlling

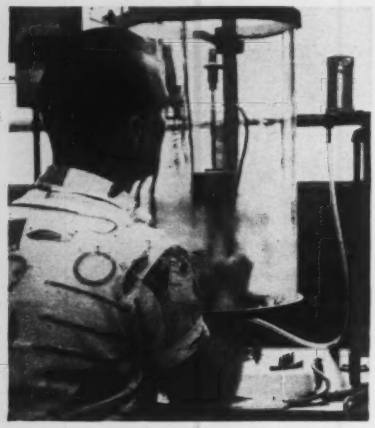
Write for Bulletin 101-R3 for complete information

AMERICAN
RECORDING CHART CO.
7142 East Condor Street · Los Angeles 22, California

SEND FOR BULLETIN NO. 101-R3

CIRCLE 118 ON READER-SERVICE CARD

Varian protects hydrogen brazing operations with J-W gas detector



Construction of Varian Associates backward wave oscillator tube involves brazing two copper tubes with silver eutectic. In the operation shown an oxygen flame in a hydrogen atmosphere flows the eutectic.

Varian protects against a build-up of an explosive gas mixture in the shop with a J-W warning system. The indicating unit (model RV, shown at right) is situated in a central place and monitors nine work stations automatically at four minute intervals.

Varian's explosive gas detector system was designed to custom requirements. If you have an explosive gas hazard in your operations, contact Johnson-Williams for information on standard models and J-W engineering service on gas warning systems.

J-W Johnson-Williams, Inc.
Palo Alto 13, California

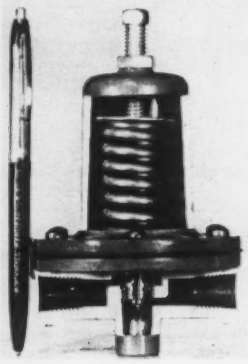
Leadership in explosion prevention since 1927

Canadian customers please write:
Safety Supply Co., Toronto, Ont.
Fleck Bros. Ltd., Vancouver, B. C.

CIRCLE 119 ON READER-SERVICE CARD

INSTRUMENT REGULATOR

New Instrument Regulator, Model 080, is especially suited for air supply lines of production line equipment such as punch presses, pneumatic tools, paint sprays, etc. Constructed

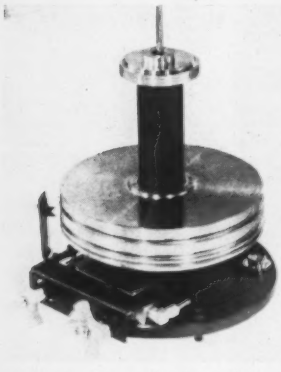


of pressure-die-cast aluminum, it is suited for a maximum inlet pressure of 250 psig and outlet pressure ranges of 0-5, 5-35 and 35-100 psig. Optional construction includes a handwheel adjustment and a ¼" side outlet tap for pressure gage mounting.—*Rockwell Mfg. Co., Meter and Valve Div.*, 400 *N. Lexington Ave., Pittsburgh* 8, *Pa.*

CIRCLE 264 ON READER-SERVICE CARD

DEAD WEIGHT GAGE

New Dead Weight Gage, Type WG, which measures pressure, using a piston loaded with weights is operated by water to avoid the contamination and nuisance of an oil reserve, although gas, oil or any liquid not corrosive to Type-416 s.s. can be used.



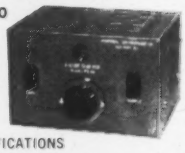
In addition, the weights rotate much more freely with water than with oil with resultant improved sensitivity or resolution. Extreme precision of piston and cylinder provides average production of 1/20 of 1% and, by selection, accuracies to 1/30 of 1% can be certified where the gage is to be used as a primary standard.—*Mansfield and Green Inc.*, 1051 *Power Ave., Cleveland* 14, *Ohio.*

CIRCLE 265 ON READER-SERVICE CARD

NEW! ELECTRONIC TEST EQUIPMENT

PHASE SHIFTER

Models PS60 & PS400



For measurement and comparison of phase angles or as a secondary phase standard

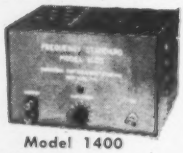
SPECIFICATIONS

RANGE	0-360° (continuously variable)
ACCURACY	± 1 degree (Higher accuracies available)
FREQUENCY	60 CPS for PS 60 400 CPS for PS 400 (other frequencies available)

FREQUENCY STANDARD

A SELF-CONTAINED FORK STABILIZED FREQUENCY SOURCE

- Accurate
- Stable
- Low Distortion
- Variable output voltage
- Compact



Model 1400

SPECIFICATIONS

ACCURACY	Available to .005%
DISTORTION	Less Than 1%
FREQUENCY	400 CPS or 1000 CPS (Other Freq. Avail.)
Dimension	6x9x6 inches
Power Supply	115 volts, 60 CPS

OTHER MODELS AVAILABLE

MODEL 600 LOW FREQUENCY STANDARD	**DESCRIPTION:** Utilizes scaling circuits to provide tuning fork accuracies at frequencies below the range of precision tuning forks.

AUTOMATIC HI-POT TESTER

Model A

FAST, ACCURATE, DIELECTRIC TESTING FOR MULTI-CONDUCTOR DEVICES

DESCRIPTION: The function of this instrument is to apply in programmed sequence a known voltage between the various conductors under test for a specific period of time and to indicate breakdowns when and where they occur.

SPECIFICATIONS

TEST VOLTAGE	0-2000 Volts RMS
TEST TIME	2-120 seconds
NUMBER OF TEST TERMINALS	11

NULL DETECTOR

Model 60B

A sensitive battery operated null detector ideal for shering bridges or other applications where complete isolation from power lines is desirable.

• Long Battery Life • High Harmonic Rejection • Shielded against external fields

SENSITIVITY: 1 microvolt for 1% deflection

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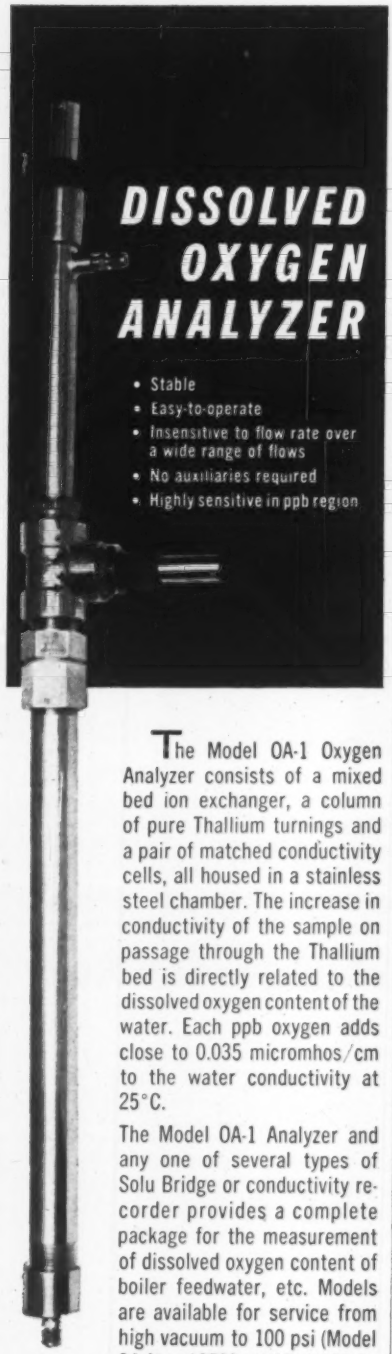
CIRCLE 120 ON READER-SERVICE CARD



The Model OA-1 Oxygen Analyzer consists of a mixed bed ion exchanger, a column of pure Thallium turnings and a pair of matched conductivity cells, all housed in a stainless steel chamber. The increase in conductivity of the sample on passage through the Thallium bed is directly related to the dissolved oxygen content of the water. Each ppb oxygen adds close to 0.035 micromhos/cm to the water conductivity at 25°C.

The Model OA-1 Analyzer and any one of several types of Solu Bridge or conductivity recorder provides a complete package for the measurement of dissolved oxygen content of boiler feedwater, etc. Models are available for service from high vacuum to 100 psi (Model OA-1) and 2500 psi (Model OA-2).

Industrial Instruments

FOR FURTHER INFORMATION WRITE

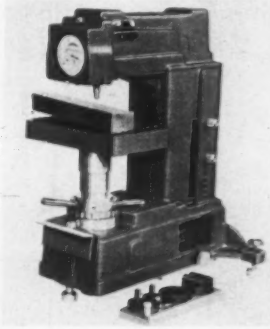
Industrial Instruments Inc.

89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 121 ON READER-SERVICE CARD

HARDNESS TESTER

New Motorized Kentrall Hardness Tester, which features greater reproducibility, is available as a combination tester that provides both

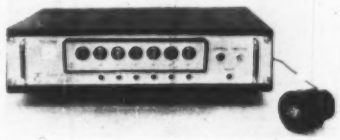


regular and superficial Rockwell hardness testing in a single machine, or as a single-purpose tester for either regular or superficial testing. —*Torsion Balance Co., Clifton, N. J.*

CIRCLE 266 ON READER-SERVICE CARD

SHAFT DIGITIZING SYSTEM

New fully-transistorized, high-speed Telepak Shaft Rotation Digitizing System offers resolution of 2000 counts/rev. It records shaft position "on-the-fly" and visually displays it in decimal digital form using six Nixie readouts. Simultaneously a load



driving memory provides digital signals to electrical readouts such as summary punch, parallel input printer, electric typewriters, tape perforator, or keypunch. System consists of an angle pulse generator and a counter/accumulator.—*Data Instruments, a div. of Telecomputing Corp., 12838 Saticoy St., North Hollywood, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

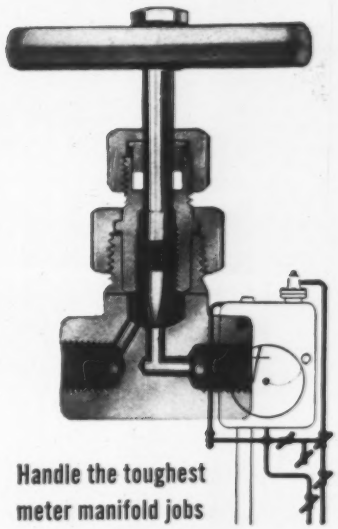
FURNACE ACCESSORIES

Six new functional accessory groups extend use of Type 2100 Thermolyne as a salt bath, oil bath, melting, vertical muffle or crucible furnace: Groups consist of two special-alloy s.-s. pots with cover for liquid heating to 1000°F and 1600°F, a safety lifting handle for the pots, a perforated s.-s. small parts basket with lifting handle, a perforated s.-s. skimmer for removing sludge or crust, a graphite melting ladle for use to 1700°F with unique no-slip lifting handle, a high-temperature refractory chamber liner, and a heavy well-insulated refractory chamber cover.—*Thermo Electric Mfg. Co., 496 Huff St., Dubuque, Iowa.*

CIRCLE 268 ON READER-SERVICE CARD

For dependable field service

SPECIFY AMERICAN® NEEDLE VALVES



Handle the toughest meter manifold jobs and corrosive field services. Eliminate gland leaks.

Teflon-packed forged steel American® Needle Valves deliver year 'round dependable service—stand up under all conditions. Stainless or carbon steel precision machined valve bodies are ideally suited for welding. Stainless steel centerless-ground valve stem design makes it simple to repack valves under pressure.

Standard valves are design rated for pressures to 5,000 psi at 70°F. Upon request, assembled valves are hydrostatically tested to 10,000 psi (twice rated working pressure) and individually inspected. Valves are also furnished with graphite-impregnated asbestos packing for temperatures above 450°F.

Angle or straight patterns—screwed or union bonnets.

Ask your American Meter representative for full details.

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General Offices:
Philadelphia 16, Pa.
Sales offices in principal cities.

CIRCLE 122 ON READER-SERVICE CARD

CONSTANT CURRENT SUPPLY

New transistorized Constant Current Supply, Model 151, that provides constant current regardless of voltage drop across a load, is particularly useful in requirements where d-c current is the independent variable and a well regulated constant current is a necessity. Output is 0.5 to 500 ma in three ranges, regulated to within 0.25% on 0-to-20-v load and 105-to-125-v a-c line. Ripple never exceeds 50 μa at peak output and is as low as 1.5 μa on lower ranges.—*Quan-Tech Labs., 60 Parsippany Blvd., Boonton, N. J.*

CIRCLE 269 ON READER-SERVICE CARD

DON'T JUST BURN about poor temperature control

Do something!

Good way to cool down this hot problem: Standardize on *reliable* Bristol pyrometer supplies and accessories. You'll have taken a *big* step toward elimination of costly temperature control down-time. Remember, even the best pyrometer system depends on its accessories.

Bristol thermocouples, protection tubes, radiation-unit accessories, refractory insulators, mounting fixtures, thermocouple extension wire, switches, and ink are *field-proven for reliability.* They are the product of 70 years of instrument-building experience and 55 years in industrial pyrometry.

Write for complete data on Bristol pyrometer accessories today. Sizes and types to fit all standard installations. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. 0.13

BRISTOL ... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 123 ON READER-SERVICE CARD

ELECTRONIC GENERATOR

New Model 250 Powertron Electronic Generator suplies 250 va of power at either a fixed frequency of 400 cps ±0.25% or a variable frequency with a range of 350-450 cps. An input jack is also provided for

output frequencies from 50-4000 cps. Output voltage is continuously variable from 0-120 v. Special features include: less than 1% output distortion, better than 1% regulation from no load to full load, and the ability to be used with loads of any power factor.—*Industrial Test Equipment Co., 55 East 11th St., New York, N.Y.*

CIRCLE 270 ON READER-SERVICE CARD

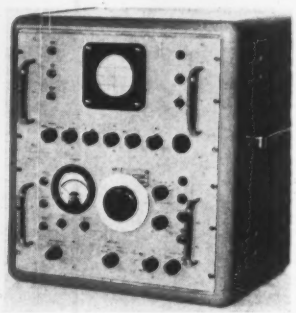
NEW COMPUTER FEATURES

New internal features for the solid-state IBM 1401 Data Processing System include Advanced Programming, Compressed Tape, and Punch Feed Read as optional features, and Dual Density Tape, and Rewind and Unload as standard.—*International Business Machines Corp., Data Processing Div., 112 East Post Rd., White Plains, N. Y.*

CIRCLE 271 ON READER-SERVICE CARD

SPECTRUM ANALYZER

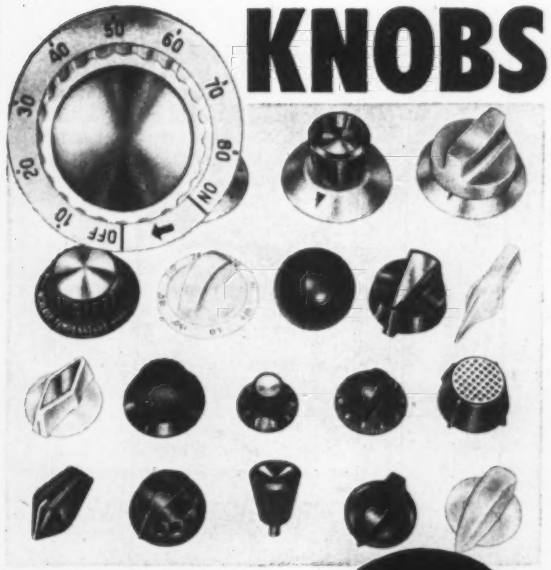
New Spectrum Analyser, Type 190, measures power level in a frequency range from 500 cps to 90 kcps with



very high sensitivity, handling signals from 0.1 v to 1 μv (100-db range), and an accuracy of ±2 db from 500 cps to 90 kc. Presentation is automatic using a thermal meter, once the frequencies of interest have been determined.—*Ferranti Electric Inc., 95 Madison Ave., Hempstead, L. I., N. Y.*

CIRCLE 272 ON READER-SERVICE CARD

KNOBS



Shown above are some of the many Rogan knobs available from stock molds. Fast delivery. Special shaft holes at nominal cost. Send for details and catalog.

FROM STOCK MOLDS OR CUSTOM MOLDED TO YOUR OWN DESIGN

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8037 N. Monticello • Skokie, Illinois

AMERICA'S FOREMOST MOLDERS AND BRANDERS OF PLASTIC KNOBS

CIRCLE 124 ON READER-SERVICE CARD

Only VALCOR makes solenoid valves of

TEFLON*

*(TFE...fluorocarbon resin)

Now, from the company that pioneered the use of Nylon and PVC in solenoid valves for corrosive service, comes a solenoid valve with a molded body and diaphragm of Teflon that is chemically inert and corrosion-resistant to virtually any corrosive medium you are now using.

Long life . . . outlasts and outperforms steel. Available in a variety of sizes and pressure ratings.

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VALCOR SOLENOID VALVES

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CIRCLE 126 ON READER-SERVICE CARD

ROTARY SWITCHES *with* QUICK-CONNECT TERMINALS

ESCO 10 amp. Type P switches are now available with quick-connect terminals for easy installation or removal by snap-on wiring.

- Standard quick-connect terminals
- Electrical ratings
  10 amp. 125 v a-c 5 amp. 125 v d-c
  5 amp. 240 v a-c 3 amp. 450 v a-c
- 1 to 8 poles; additional pole applications upon request
- base mounting or panel mounting
- supplied with snap or detent action

For details write for Bulletin No. 20 today.

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

CIRCLE 125 ON READER-SERVICE CARD

Measure any temperature from −200°F. to +600°F. with one instrument

Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200°F. to +600°F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

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CIRCLE 127 ON READER-SERVICE CARD

OUR TWENTY-FIFTH ANNIVERSARY

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Gas Density Detector

- NO CALIBRATION REQUIRED
- LINEAR ACROSS BROAD RANGES OF CONCENTRATION
- REQUIRES NO SCARCE OR COSTLY CARRIER GASES

Now a practical reality for 1960! Researchers at Standard Oil Company (Indiana) have designed a simple density detector that fulfills all these requirements. In cooperation with them, GOW-MAC has produced a commercial prototype.

The Gas Density Detector is the only one in use today that measures a single additive physical property of the chromatography gas, i.e., a property that depends only upon the number and kind of atoms in the molecule. Knowing the molecular weight of the components, the chromatographic peak areas can be converted directly into weight per cent. If the molecular weights are unknown, they can be determined by the Gas Density Detector. Measurements made by the Gas Density Detector are closely comparable to those from thermal conductivity cells. Precision and accuracy are excellent.

SEE DECEMBER ISSUE, ANALYTICAL CHEMISTRY—
"The composition of Crude Oil through Seven Carbons as Determined by Gas Chromatography" by Martin and Winters.

VISIT BOOTH 530 at the I.S.A. SHOW
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Write for full information; address inquiries to Department **AN**

GOW-MAC INSTRUMENT COMPANY
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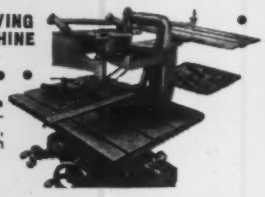
1935-1960 OUR TWENTY-FIFTH ANNIVERSARY

CIRCLE 128 ON READER-SERVICE CARD

how to ENGRAVE PANELS & SIGNS to 30" wide by any length

Use the LOW COST precision built PREIS-PANTO 2D-4 ENGRAVING MACHINE



It does the work of larger machines, costing much more.

- Pantograph is graduated with reductions from 1:1 to 100:1 and will reduce to any size to infinity.
- Pantograph and spindle link joints equipped with precision ball bearings throughout.
- Precision ball bearing cutter spindle
- Collet capacity from 1/10" to 1/4" and standard taper shank cutters
- Six spindle speeds—5,000 to 14,000 rpm
- All feed-screw dials graduated in .001"

TRADE MARK PANTO

Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS ENGRAVING MACHINE CO.
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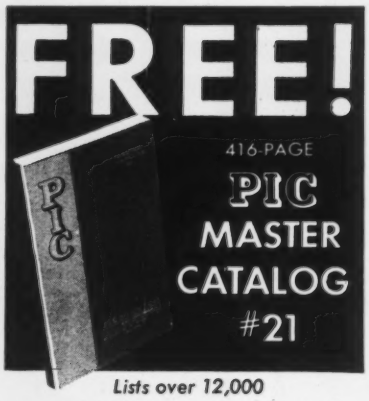

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CIRCLE 130 ON READER-SERVICE CARD

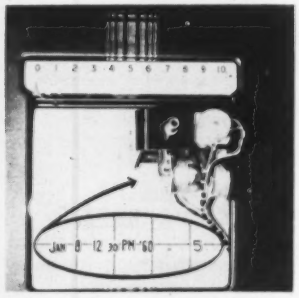
SHAFT ANGLE ENCODER

New Dychroverter Model DV-SC11A, a Shaft Angle Digitizer has a precision code disc containing sine and cosine information in cyclic binary form. Accuracy of the instrument is 2^{11} ± one bit of the sine or cosine value. The instrument has a size-23 or -35 synchro mount with an outer diameter of 3¾" and an overall length of 6½".—*Dychro Corp., 49 Walnut St., Wellesley 81, Mass.*

CIRCLE 273 ON READER-SERVICE CARD

STRIP CHART PRINTER

New kit-form printing device, the Identichart RI-5, prints date, time, and remotely-selected code number or letter on strip charts. Up to 12 code numbers are available, selected by remote selector switch, stepping relay,

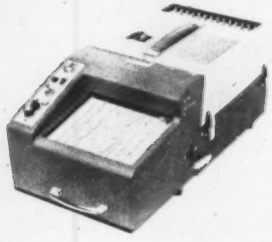


or other combination of contacts. Kit includes rubber for the chart platen, mounting screws, plexiglas window to replace the original one in the recorder door.—*Royson Engineering Co., Jacksonville Rd. and Montgomery Ave., Hatboro, Penna.*

CIRCLE 274 ON READER-SERVICE CARD

RECORDING OSCILLOGRAPH

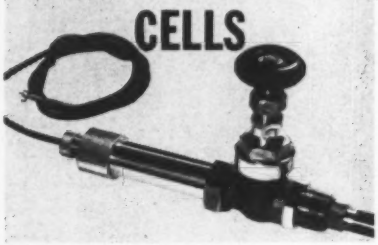
New low-cost Model 621 HT (horizontal table), a Direct-Recording Oscillograph, puts up to fourteen data traces on 6"-wide recording paper. Reversible transport can be operated



in three speed ranges, from 0.2"/min to 60"/sec. Using standard miniature light-beam type galvanometers with frequency response from dc to 10,000 cps (natural response) and 6,000-cps flat response, the record is brought out by exposure to ambient fluorescent lighting without chemicals or heat.—*Midwestern Instruments, Box 7186, Tulsa, Okla.*

CIRCLE 275 ON READER-SERVICE CARD

ONE SOURCE FOR ALL YOUR CONDUCTIVITY CELLS



BODY MATERIAL

Choose from the widest range of body materials...polystyrene, lucite, epoxy, nylon, polyethylene, bakelite, hard-rubber, Teflon, Kel-F, stainless-steel, Monel, nickel and glass to meet every requirement for temperature, pressure and corrosion resistance.

PHYSICAL RANGE

Select the cell specifically designed to meet your application requirements... no need to settle for a universal compromise. Industrial Instruments manufactures conductivity cells for operation under pressures up to 7000 PSI.

CONDUCTIVITY RANGE

The most comprehensive line of cell ranges and constants available anywhere for every application from measurement of ultra-pure water to concentrated solutions of highly corrosive acids, alkalis and salts.

ELECTRODE MATERIALS

Nickel, platinum, graphite, gold or tin ...each one tailored to perform a specific job properly. Submit your particular requirements to us. Over twenty years' experience in the electrolytic conductivity field.

Write on your letterhead for our new Conductivity Catalog.

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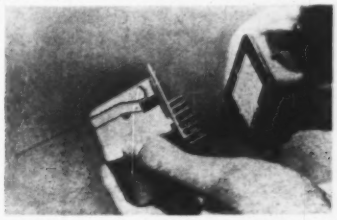
89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 131 ON READER-SERVICE CARD

VARIABLE RESISTANCE

New Regohm Transducer, able to directly control up to ¼ kw of power, and responsive to less than 0.0001" of mechanical displacement, is a direct-acting unit in a compact package

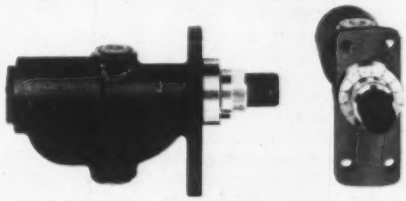


capable of any mounting position. Can be actuated by a cam, a heat-sensing bimetal, by fluid pressure on bellows, tension developed by the winding of paper, tape or film onto reels, or a vane deflected by liquid or gas flow.—*Electric Regulator Corp., Pearl St., Norwalk, Conn.*

CIRCLE 276 ON READER-SERVICE CARD

FLOW REGULATOR

New Flow Regulator, which controls flow as low as 35 cc/min, has a built-in check valve which provides

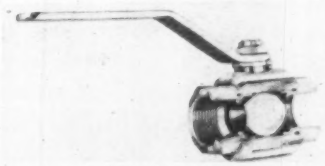


free flow with minimum pressure drop in reverse direction. Valve is adjustable between 2 and 90 cu in/min. Details in bulletin.—*Fluid Power Accessories, Inc., 2051 Railroad Ave., Glenview, Ill.*

CIRCLE 277 ON READER-SERVICE CARD

BALL VALVES

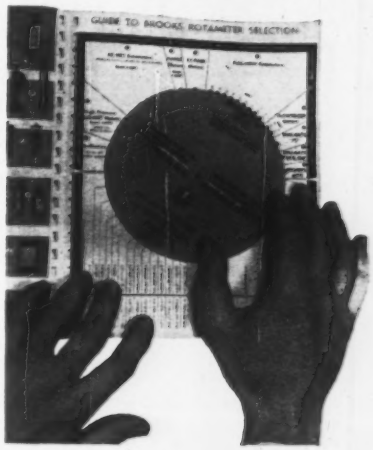
New line of Ball Valves includes type McCannaseal, and McCannaflo (see illustration), both of which provide the full flow of a gate valve, the tight shut-off of a globe or needle valve, and the quick quarter turn of



the plug valve. Operating temperatures are up to 350°F and pressures up to 700 psi for the McCannaseal, and up to 1,000 psi for the McCannaflo. They handle practically all fluids, semi-solids, compressed gases, and compressed air. Pressure may be applied from either side, and the greater the pressure the tighter the seal.—*Hills-McCanna Co., 4600 West Touhy Ave., Chicago 46, Ill.*

CIRCLE 278 ON READER-SERVICE CARD

HANDY SELECTION GUIDE GIVES ROTAMETER SPECIFICATIONS WITH JUST A TURN OF A DIAL



It's yours for the asking . . . from Brooks

Here is a quick, convenient way to compare rotameter specifications to find the correct model for any particular application.

With the Brooks Rotameter Selection Guide, you can determine essential information at a glance. You simply set the chart dial at the required flow range, and other pertinent data — model, size, maximum operating temperature and pressure — are conveniently presented.

The Guide covers the full line of Brooks Rotameters . . . a line that includes everything from rugged armored meters for large flows, high temperatures and pressures, to "miniature" purge meters for small flow indication.

All in all, you'll find the Selection Guide a genuinely useful reference manual. To get a copy, request Bulletin 110.

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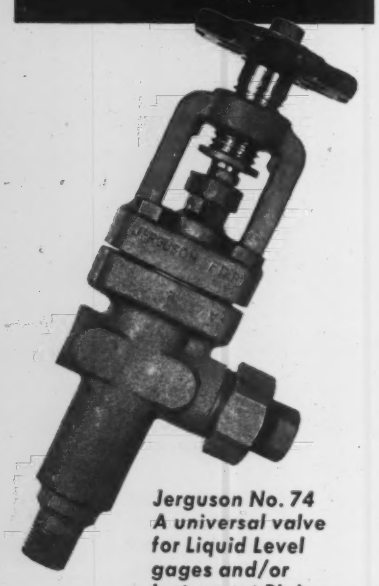
CIRCLE 132 ON READER-SERVICE CARD

Here is a NEW
Jerguson
ALL-PURPOSE ANGLE VALVE



Jerguson No. 74 A universal valve for Liquid Level gages and/or Instrument Piping and General Use

This unique New Angle Valve has unusual advantages. A universal valve, ideal for liquid level gages . . . simply add our pipe plug with integral bleed (No. 74G) for the ideal valve for instrument piping and general use.

Combines Advantages of single-piece forged body and bonnet flange, simplified OS&Y bonnet and reciprocating stem in one valve.

Forged yoke supports stem away from valve body; separate forged gland-follower bears on packing, independent of yoke. Stem thread outside, not affected by temperature or liquid. Stem works freely, no chance of freezing.

Reciprocating Backseating Stem: Works in to-and-fro motion with no rotating action; gives perfect seating, eliminates wear from galling. Backseating eliminates packing contamination from liquid; can be repacked under pressure. Teflon seating available.

Write for catalog sheet on Jerguson No. 74 Valve.

JERGUSON

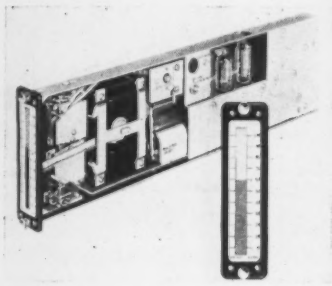
Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

CIRCLE 133 ON READER-SERVICE CARD

RIBBON INDICATOR

New Electronic Ribbon Indicator, Model A22M, measuring only 2" x 5⅞", is a high-amplification, null-balance device that operates on the



common 0-0.5 vac signal with accuracy of ±1% of full signal input. Amplifier assembly is a self-contained unit that can be removed in its entirety.—*Swartwout Div., Crane Co., 18511 Euclid Ave., Cleveland 12, Ohio.*

CIRCLE 279 ON READER-SERVICE CARD

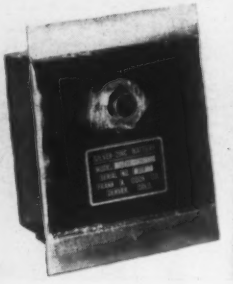
POLYETHYLENE TUBING

New Parker-POL polyethylene tubing is available in ¼" OD x 0.040" wall thickness, ⅛" x 0.062", ⅜" x 0.062", and ½" x 0.062" with black as standard and other colors available. Exceptionally flexible, tubing is easy to connect with brass or aluminum Intru-lok fittings. Chemically resistant, non-toxic, and odorless. Catalog Sheet 4395A11 gives details.—*Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.*

CIRCLE 280 ON READER-SERVICE CARD

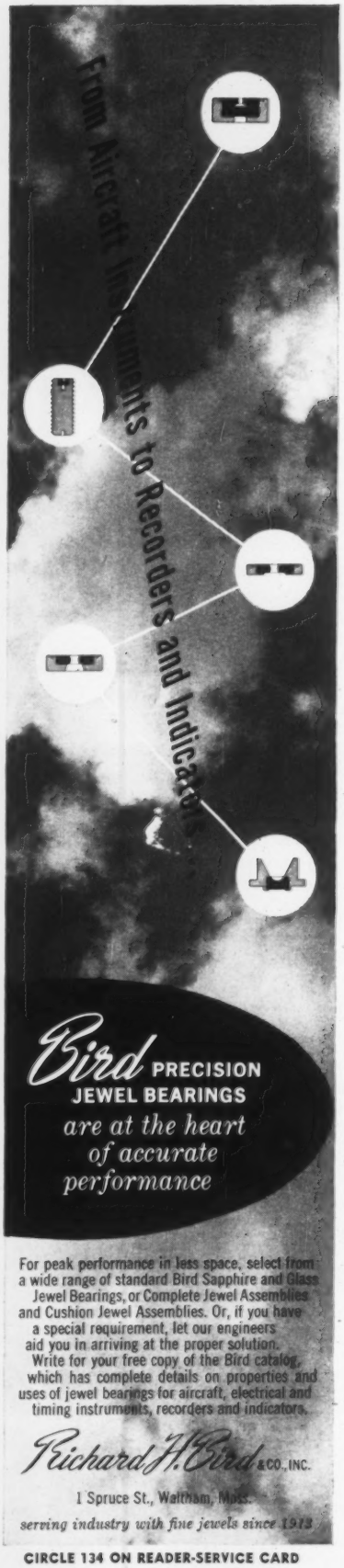
SILVER-ZINC BATTERY

New, ultra-compact, automatically activated Silver-Zinc Battery, Model P63A, provides one amp-hr of 28-v current for missiles. Contains 19 foil-plate cells which provide 6 amp current (15 amp max.) Discharge time



is 10 min. A solid-propellant furnishes automatic activation in 0.2 sec. The signal required for activation is 28 v at 1 amp. Withstands vibration to 8 G's, acceleration to 90 G's, and shock to 30 G's.—*Cook Batteries, a sub. of Telecomputing Corp., 3850 Olive St., Denver 7, Colo.*

CIRCLE 281 ON READER-SERVICE CARD



***Bird* PRECISION JEWEL BEARINGS** *are at the heart of accurate performance*

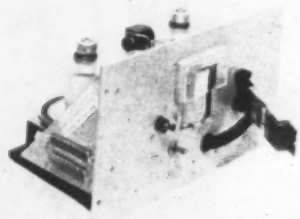
For peak performance in less space, select from a wide range of standard Bird Sapphire and Glass Jewel Bearings, or Complete Jewel Assemblies and Cushion Jewel Assemblies. Or, if you have a special requirement, let our engineers aid you in arriving at the proper solution. Write for your free copy of the Bird catalog, which has complete details on properties and uses of jewel bearings for aircraft, electrical and timing instruments, recorders and indicators.

Richard H. Bird & CO., INC.
1 Spruce St., Waltham, Mass.
serving industry with fine jewels since 1913

CIRCLE 134 ON READER-SERVICE CARD

PROGRAMMER

New Model TP-201A, an 80-bit, bi-directional Punched Tape Programmer, is claimed to provide great advantages over the conventional rotary switching equipment. Using 2"-

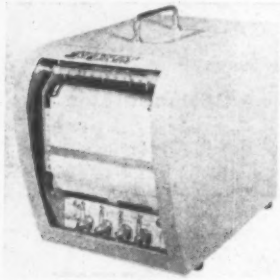


wide tape (with 1" for punched information and 1" for printed information) to allow visual selection of any 1" frame within 250 ft of stored tape, it has a bi-directional electrical drive system which employs positive detent action for accurate positioning of the tape.—*Electronic Engineering Co. of Calif., 1601 East Chestnut Ave., Santa Ana, Calif.*

CIRCLE 282 ON READER-SERVICE CARD

PORTABLE RECORDER

New line of low-cost Portable Potentiometer Recorders, with 6" chart for strain gage or thermocouple monitoring, features ball point pen, one-

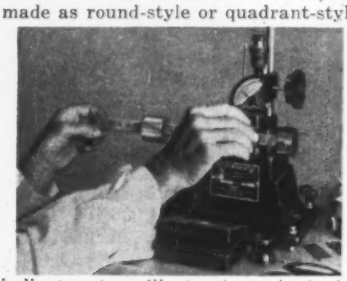


mv span preamp, resistance-bulb bridge for temperature measurements up to four recording channels, and ¼% sensitivity. Bulletin 10-20 contains details.—*Systron Corp., 950 Galindo St., Concord, Calif.*

CIRCLE 283 ON READER-SERVICE CARD

DUROMETER CALIBRATOR

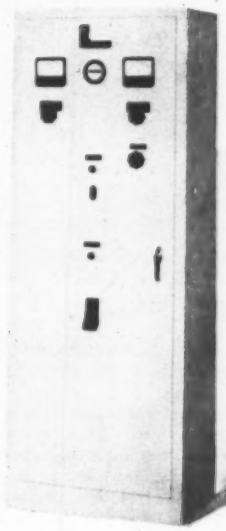
New Durocalibrator, Model SD 1, an instrument to calibrate Shore Durometer rubber-hardness testers, is made as round-style or quadrant-style



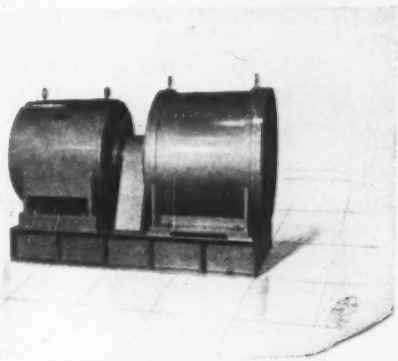
indicator (see illustration), both described in Bulletin R-16.—*Shore Instrument & Mfg. Co., Inc., 90-35 Van Wyck Expressway, Jamaica 35, N. Y.*

CIRCLE 284 ON READER-SERVICE CARD

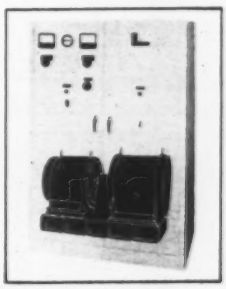
FOR PRECISE 400-CYCLE POWER



Specify Kearfott Motor Generator Set Systems



Kearfott 60-to-400 cycle motor generator frequency converters are in active use wherever precise 400-cycle power must be supplied . . . including laboratories and in such other representative applications as production testing, high speed tool operation and ground support. These generator systems, which consist of a 60 cycle synchronous motor and a 400 cycle generator, can be supplied with controls and generator as an integral, compact unit—or with controls and generator separately located.



PERFORMANCE SPECIFICATIONS

Frequency: 400 cycles under any rated load condition with 60 cycle input.

Voltage Regulation: Within ±1% of rated voltage when (1) load varies between no-load and 125% of rated load, and/or (2) load power factor varies between 0.8 lagging and unity, and/or (3) equipment temperature varies after approximately 10 minutes' operation.

Voltage Recovery: When rated load is suddenly applied or removed, voltage will return to and remain within regulating band within 0.25 seconds.

Voltage Adjustment: Continuously adjustable to ±10% of rated value.

Deviation Factor: Maximum 4% between no load and full load.

Overload: Equipment delivers 125% of rated load for 2 hours.

Amplitude Modulation: Maximum 1% of peak-to-peak voltage at any load between no load and full load, at any power factor between 0.8 lagging and unity.

Frequency Modulation: Maximum 0.5% at any load from no load to 125% of rated load.

KEARFOTT DIVISION

GENERAL PRECISION, INC.

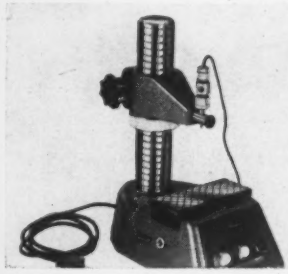
LITTLE FALLS, NEW JERSEY

Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

CIRCLE 135 ON READER-SERVICE CARD

ELECTRIC INSPECTION GAGE

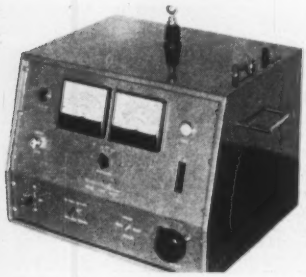
New electric Comparator Gage manufactured by Mauser has limit contacts built into the gaging unit and detects off-size conditions within 20 millionths of an inch accurately and instantly. Signal lights report accurately oversize as well as undersize and correct size by flashing of green, red, or yellow light. Another very important advantage of electrical gaging is the low initial cost coupled with the elimination of installation expenses as well as costly maintenance.—*Scherr-Tumico Co.*, 200 *Lafayette St., New York* 12, *N. Y.*



CIRCLE 287 ON READER-SERVICE CARD

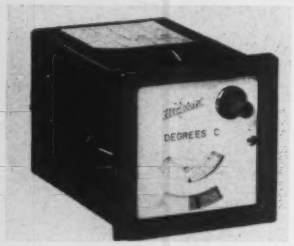
INSULATION LEAKAGE TESTER

New HYPOT series of bench-type, semi-portable, high-potential Test Sets with outputs to 30 kv, for determining dielectric strength in electrical power, electronic and communication circuits, components, etc., is made with either a-c or d-c output and continuously variable voltage control. Output voltage and insulation leakage current are indicated on separate meters.—*Associated Research Inc.*, 3777 *W. Belmont Ave., Chicago* 18, *Ill.*



CIRCLE 285 ON READER-SERVICE CARD

SWITCHING GALVANOMETER

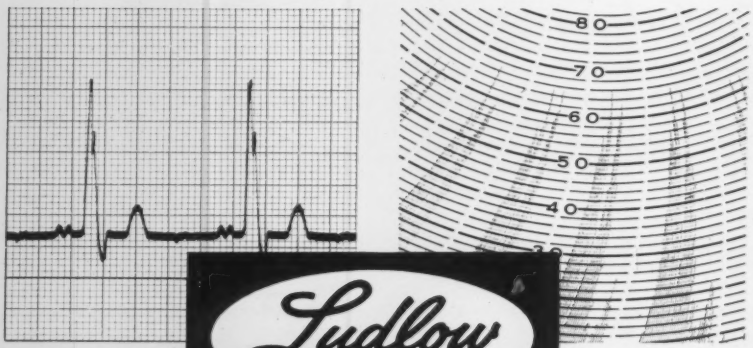


New Switching Galvanometer, for control systems where the energizing signal is too slight to energize conventional relays, features a friction-free movement which requires less torque to perform the signaling operation. Utilizing the taut-band meter movement, it energizes an auxiliary relay (rated 50 w), and can directly control a magnetic switch. Measures 2.75" x 2.75" x 4".—*Hickok Electrical Instrument Co.*, 10514 *Dupont Ave., Cleveland* 8, *Ohio.*

CIRCLE 288 ON READER-SERVICE CARD

for HEAT-Sensitive systems

for PRESSURE-Sensitive systems



Ludlow

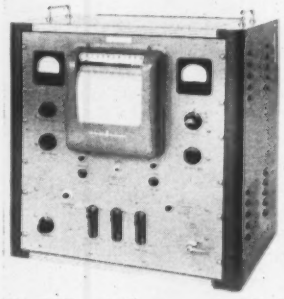
CUSTOM
CHART PAPERS

You get the full potential from your recording systems when you use custom-made chart papers by Ludlow. Precision engineering assures constant fidelity. Write for free samples and literature or tell us your requirements. Ludlow Papers, Ware, Massachusetts, Dept. 162.

CIRCLE 136 ON READER-SERVICE CARD

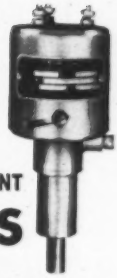
GAS MONITOR

New H.F.I. (Hydrogen Flame Ionization Method) Gas Monitor for total hydrocarbon gases has no filaments, no contamination, no columns, no thermal cells, and features small drift (which is detectable only on the more sensitive ranges of attenuation), and sensitivity to methane of 1 to 5 ppm in air. It has seven scales of attenuation (1-3-10-30-100-300 & 1000) for percentages of gas from 0.001% to high concentrations. Its low-volume hydrogen requirement is self-generated and self-consumed as used.—*Well Logging Equipment Mfg. Co.*, 3915 *Tharp St., Houston* 3, *Tex.*



CIRCLE 286 ON READER-SERVICE CARD

SPEED SENSITIVE



1, 2 & 3 ELEMENT SWITCHES

OVERSPEED

One S.P.D.T. switch to trip at speeds between 500 and 6,000 RPM.

OVER AND UNDERSPEEDS

Two S.P.D.T. switches to trip at two different speeds between 300 and 6,000 RPM.

UNDERSPEED

One S.P.D.T. switch to trip at speeds as low as 250 RPM. Maximum operating speed 5,000 RPM.

OVER INTERMEDIATE AND UNDERSPEED

Three S.P.D.T. switches to trip at three different speeds between 350 and 6,000 RPM.

EXPLOSION PROOF AVAILABLE

The switches listed above are available with explosion proof containers that meet all of the specifications of Class 1, Group D, explosion proof equipment.

For further information ask for Bulletin 504 and 504 A.

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE, SKOKIE, ILLINOIS

CIRCLE 137 ON READER-SERVICE CARD

Leitz The NEW Concept in AUTO-COLLIMATORS

- For testing angular deviations within tolerances of 1/10 second of arc.
- Short and compact design of 13" overall length.
- Measurements in 2 planes obtained by merely rotating eyepiece against positive stops.
- Range of focus 0-50 feet.

Request circular 85-200

OPTO-METRIC TOOLS, INC.
137 1A VARICK STREET, NEW YORK 13, N. Y.

CIRCLE 139 ON READER-SERVICE CARD

New "400 SERIES"

ZERO-MAX *Stepless Variable Speed*

Zero-Max "400 Series", a redesign of the complete line, gives you stepless variable speed control with a finger's touch. Over 250 fractional horsepower models and types (1/15 hp thru ¾ hp) with or without motors, reverse or gearhead – output range from zero to 1200 rpm with 1800 rpm input. Zero-Max gives smooth, stable drive and constant torque from 2½ to 450 inch-pounds.

Change speeds instantly, running or not. Truly stepless – zero to maximum. Lever, screw, vernier or remote control. Lever control provides fast yet precise control. Instant reverse and neutral.

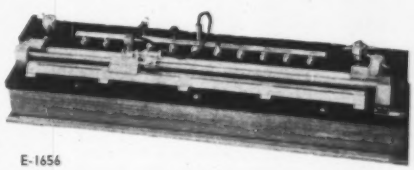
Send for free catalog on the new Zero-Max "400 Series" and name of your nearest representative.

THE ZERO-MAX® COMPANY
Subsidiary of REVCO, INC.
1942 Lyndale Ave. So., Minneapolis 5, Minn., FR 4-5520

CIRCLE 138 ON READER-SERVICE CARD

GRAY KELVIN BRIDGES

FOR
ACCURATE MEASUREMENT
OF
LOW RESISTANCE



E-1656

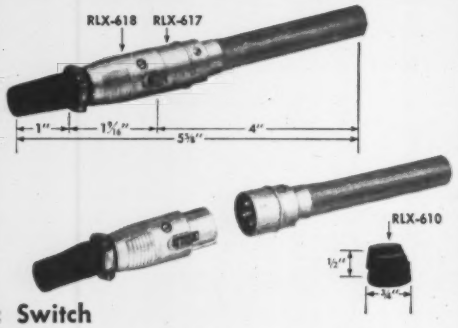
VARIABLE LOW RESISTANCE
STANDARD 0.001OHM
READABLE TO 1 MICRO-OHM
USED WITH E-1655B RATIO BOX
TO MEASURE FROM
0.01 MICRO-OHM TO 1.11 OHMS

SEND FOR BULLETIN 113

GRAY INSTRUMENT COMPANY
448 MILL ROAD
ANDALUSIA, PA.

CIRCLE 140 ON READER-SERVICE CARD

POST DECITRON ELECTRONIC PRODUCTS



NEW!
MH-2-P Magnetic Switch

A new and improved sensing device . . . neatly contained in an epoxy resin shell. The MH-2-P is ideal for industrial applications and is easier to mount in areas of limited access. A quick disconnect Cannon connector eliminates elbow type construction.

The new epoxy resin housing results in less magnetic flux and increased sensitivity. As a consequence, smaller magnets can be used and manufacturer reports a minimum magnetic field transient time of only 8 milliseconds is needed to activate the switch. Operating life is in excess of one billion operations.

Write For Bulletin MH-2-P

Decitron

ELECTRONIC PRODUCTS DIVISION

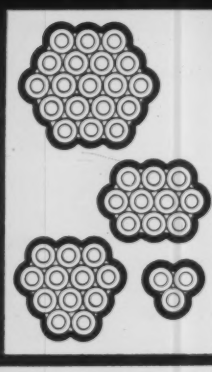
Post Machinery Co. | 175 Eliot St., Beverly, Mass.

CIRCLE 141 ON READER-SERVICE CARD

PYRAMID "INSTRUPACK"

(TUBING BUNDLES)

POLYETHYLENE TUBES ENCLOSED IN VIRGIN PVC (VINYL) SHEATH



STANDARD

Tubing — 1/4" O.D. x .040" Wall, .045" or .062" Sheath

Tubing — 3/8" O.D. x .062" Wall, .045" or .062" Sheath

Tough vinyl outer sheath with excellent chemical atmospheric resistance. Inside tubes are Polyethylene available in standard colors with pair of telephone wire leads. Lengths to requirements.

STOCK POLYETHYLENE TUBING—1/4" O.D. x .040" wall and 3/8" O.D. x .062" wall, in standard colors.

PLASTIC COATED METAL TUBING—standards and specials to order.

Write for Bulletin PPI-59.

PYRAMID PLASTICS, INC.

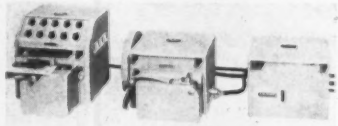
PPI

556 W. Polk St., Chicago 7, Ill.

CIRCLE 142 ON READER-SERVICE CARD

DATA COLLECTING SYSTEM

New Collectadata System uses coded punched holes on tape, edge card, tab card, or form card, and multiple readers (transmitters), then channels information by cable to a

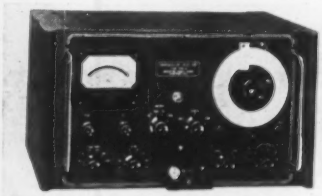


data collecting center where it is reproduced in a continuous punched tape on a receiver. This tape is used on other automatic equipment such as a computer, tape-to-card converter, or Flexowriter to prepare documents used for scheduling, job priorities, anticipated shortages.—*Friden Inc., 2350 Washington Ave., San Leandro, Calif.*

CIRCLE 289 ON READER-SERVICE CARD

TRANSISTOR TEST SET

New Type 275-A Test Set, an instrument for the precise measurement of basic transistor parameters can also be used to measure the characteristics of diodes and other semi-con-

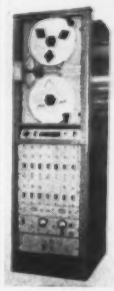


ductor devices. Parameters measured are: (1) Alpha (h_{fb}), (2) Beta (H_{fe}), (3) Input Resistance (h_{ib}). Features include unique null-type measuring circuit, accurate measurements at extremely low emitter currents, and built-in adjustable, metered collector and emitter power supplies. Both NPN and PNP transistors can be tested.—*Boonton Radio Corp., Boonton, N. J.*

CIRCLE 290 ON READER-SERVICE CARD

RECORDER/REPRODUCER

New Model 5-752A Magnetic Tape Recorder/Reproducer (developed by the DataTape Div.) features (1) five

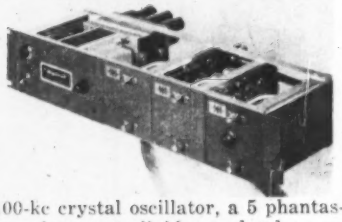


modes of recording, (2) an all-welded steel cabinet, and (3) an automatic ready circuit.—*Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 291 ON READER-SERVICE CARD

DECADE FREQUENCY SOURCE

New DLI-208 Decade Frequency Source which provides 6 switch-selected frequencies in decade steps from 100 kc to 1 cps, consists of a



100-kc crystal oscillator, a 5 phantastron frequency divider, and a d-c power supply. Two modes of operation are available: (1) the output is a continuous chain of negative pulses at the selected frequency; or (2) the output is gated from a binary plate or similar sources. Output frequencies are 100 kc, 10 kc, 100 cps, 10 cps, and 1 cps.—*Electro Precision Corp., Arkadelphia, Ark.*

CIRCLE 292 ON READER-SERVICE CARD

HAND PERSPIRATION METER

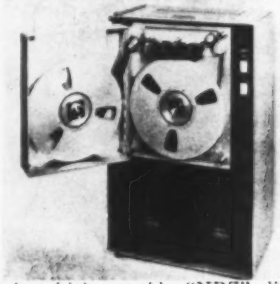
New Permeter instantly measures hand perspiration of personnel who are considered for assignments to deli-

cate handling operations. A precision instrument, physicians will find it valuable. Claimed to be widely used in other countries.—*Ameresco Inc., 7 Center Ave., Little Falls, N. J.*

CIRCLE 293 ON READER-SERVICE CARD

DIGITAL RECORDER

New 16-track portable Digital Magnetic Tape Recorder/Reproducer, Model PS 216-D, measuring 16½" W x 25½" H x 14" D, features modular construction and printed-circuit



boards which provide "NRZ" digital read-and-write amplifiers in compact solid-state plug-in form. 1" tape and speeds from 1⅞ to 60"/sec are standard.—*Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.*

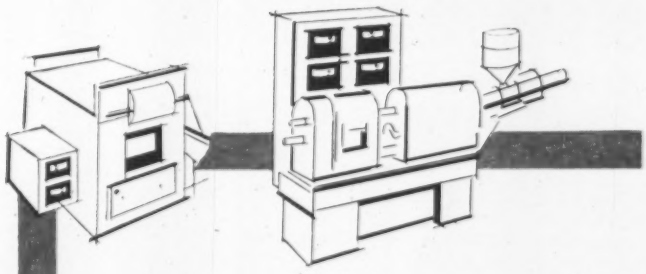
CIRCLE 294 ON READER-SERVICE CARD

Why it pays to see that

WEST Instruments are in

Original Equipment

using Temperature Control

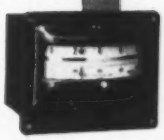


Makers say

"Our equipment sells best on performance, including ease of operation and maintenance. We can't risk dissatisfaction that stems from components, such as instruments. We're safer with Gardsman, by West, and their world-wide service."

Users say

"Instrumentation can be the key to overall efficiency of major equipment. West temperature controllers work better than most, definitely save on several counts . . . including initial cost. It pays to specify."



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Presents Its
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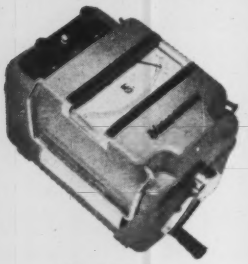
Voltmeter and Ammeter

Model MPF


Model L-5

DC: Model MPF
AC: Models SPF CPF
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Insulation Tester
Model L-5

Vacuum Thermocouple
(Instrument type)
Models VL-25, VL-7

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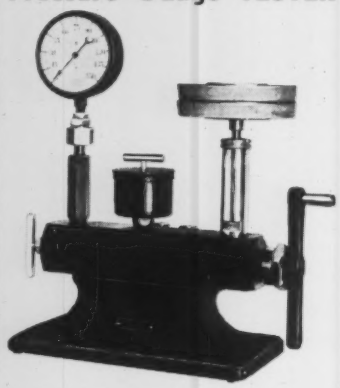

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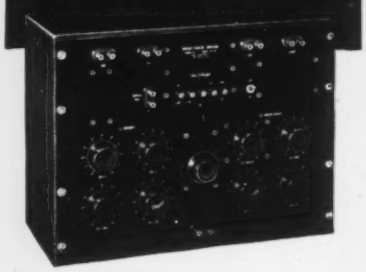

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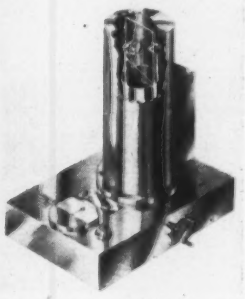
FUSED QUARTZ PRESS GAGE

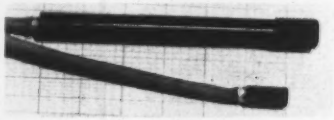
New Fused Quartz Pressure Gauge is claimed to have lower hysteresis than any other type gage, reproducibility of pressures to the same degree of accuracy, one minute or ten days from the initial reading, and a low temperature coefficient. Available in four pressure ranges, 0-1", 0-40", 0-80", and 0-120" Hg. Bulletin contains details.—*Buck Instrument Co., Dept. M, Box* 357, *Boulder, Colo.*



CIRCLE 295 ON READER-SERVICE CARD

TEMPERATURE SENSOR

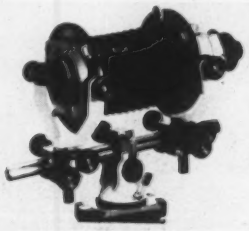
New Temperature Sensor Delta-Couple Model B1, for in-wall locations of steel structures having a section thickness of ¼" or greater, is made with body materials of 1020 steel, ASTM-A7 steel, 4130 steel, and Type 303 s.s. Chromel-alumel is offered as the standard junction material.—*Advanced Technology Labs., a div. of American-Standard,* 369 *Whisman Rd., Mountain View, Calif.*



CIRCLE 296 ON READER-SERVICE CARD

35MM VIEW CAMERA

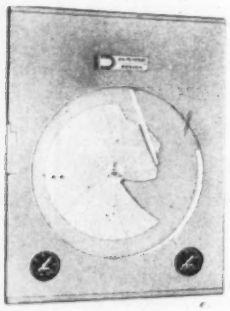
New Kennedy K-I Monobar 35-mm View Camera, being marketed under an agreement with Ilford, Inc., New York, features full-frame ground glass viewing, fine magnifier focusing, a rotating back, and quick-change magazines. Available in two models: the Universal type as described, and the Fixed type, a much simpler version. Standard equipment on both cameras is a 4" Dallmeyer lens f/4.5 in a Compur shutter with speeds of 1 to 1/500 sec., and M-X synchronization.—*Fairchild Camera and Instrument Corp., Industrial Products Div.,* 580 *Midland Ave., Yonkers, N. Y.*



CIRCLE 297 ON READER-SERVICE CARD

PROGRAM TRANSMITTER

New Pneumatic Program Transmitter, Model 7002, with interchangeable cams offering a choice of 1-, 8-, 12-, 24-hour, and 7-day cam drives, handles one or two transmission sys-

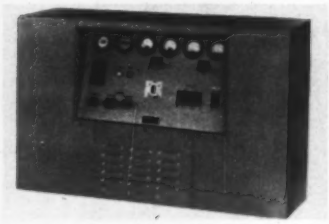


tems, transmits a 3-15-psig pneumatic signal, and can be used with single or double cams. Features include sturdy bridge-type pointer suspension, all internal components mounted on baseplate, and dust- and moisture-resistant metal cabinet.—*Weston Instruments Div., Daystrom, Incorporated, 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 298 ON READER-SERVICE CARD

AC-AC MOTOR-ALTERNATOR

New line of precisely-regulated Motor-Alternators from 5 kw to 40 kw (6.25 kva to 50 kva) provides stable a-c line power at either 60 cps or 400 cps (single or 3-phase) when driven by even the most erratic commercial



power lines. Sets are specifically intended for application with electronic computers, missile ground systems, industrial automation, processing equipment, telemetry and guidance systems, etc. Full details are given in Bulletin RPAA-5909.—*Electric Specialty Co., 206 South St., Stamford, Conn.*

CIRCLE 299 ON READER-SERVICE CARD

SOLID-STATE POWER SUPPLY

New transistorized Power Supply for labs features input voltage of 95 to 135 vac, rms, 60 cps, single phase; output voltage range from 0-50 vdc, continuously variable; output current from 0 to ½ amp dc; regulation of 0.02% no load to full load; ripple of 4 mv, rms; and size 5" x 5" x 6".—*Autotronics, Inc., Dept. 23, Box 208, Florissant, Mo.*

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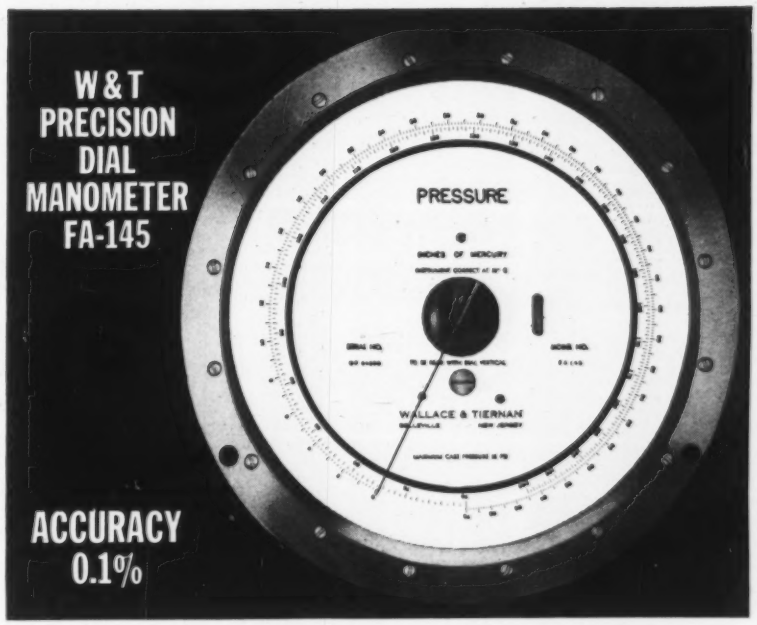

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Accuracy:	1/1000 of full scale
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Ranges:	0 to 120 inches of water (min.) 0 to 300 inches of mercury (max.) Other intermediate ranges available
Scale Length:	45 inch scale in two revolutions
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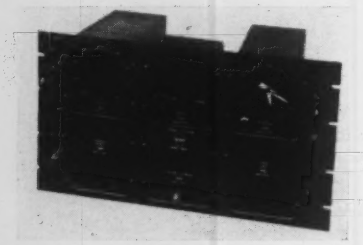
MANOMETER—CIRCLE 147 ON READER-SERVICE CARD
FEEDERS—CIRCLE 148 ON READER-SERVICE CARD

PRECISION TIMING SYSTEM

New modular Transistorized Timing System is accurate within 0.1 sec/week. Powered by 24-v batteries to make it independent of local power fluctuations and to provide a capability for portable operation, its individ-



ual modules, 7" x 5" x 4" in size, include a crystal- and oven-controlled frequency standard; a frequency divider which provides precise 60 cps; a stroboscope on whose scale WWV signals appear visually; a power amplifier unit; a clock and photocell-gated programmer which provides 10-sec, 1-min, 30-min, and 1-hour timing pulses; and a control unit containing a speaker for aural monitoring of externally received WWV signals.—*Geotechnical Corp., Box* 28277, *Dallas* 28, *Texas.*

CIRCLE 301 ON READER-SERVICE CARD

PHOTOELASTIC STRAIN GAGE

New B-L-H Strainline Photoelastic Strain Gage, a direct-reading uniaxial strain indicator, indicates axial strain in the direction of gage application only and has virtually zero lateral

sensitivity. In addition to axial static and dynamic strains, lateral bending and torque are also indicated. No external instrumentation or connections are required. Has built-in polarizers. Type A-75-10 has ¾" gage length; Type A-200-10 has 2" gage length.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div.,* 42 *Fourth Ave., Waltham* 54, *Mass.*

CIRCLE 302 ON READER-SERVICE CARD

IMAGE STORAGE SYSTEM

New Electrostore system instantly stores and immediately recalls a television picture by means of an electrostatic storage tube without use of

film, tape or other expendable material, and does not require developing or other processing. Input and read-out are composite video of standard amplitude and polarity. Input and ouput video bandwidths are 8 Mc and overall resolution exceeds that of a conventional TV system.—*Image Instruments, Inc.,* 2300 *Washington St., Newton Lower Falls* 62, *Mass.*

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PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
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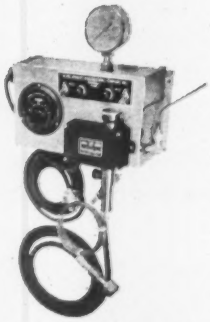
NEW DEVELCO CO_2 CONTROL UNIT
FOR HOT-COLD CHAMBERS
FEATURING UNIQUE DEVELCO-PULSE
FOR CLOSE TEMPERATURE CONTROL

Convert your low temperature chamber or oven to liquid CO_2 cooling.



CONTROL UNIT contains complete controls for liquid CO_2 cooling and electric heating. Precise temperature control is now made possible by DEVELCO-PULSE. Plug-in connections for thermostat, fan, and heaters. Basic unit available with different types of thermostatic controls to meet users requirements.

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A simple, direct reading on the Alnor Velometer gives you an instant measure of air flow speed through grilles, ducts, furnaces, spray booths, or in the open.

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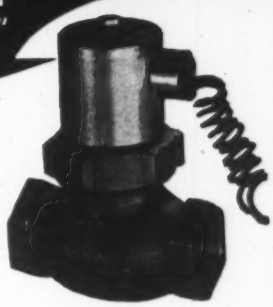

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GOULD SOLENOID VALVES — VELVETROL

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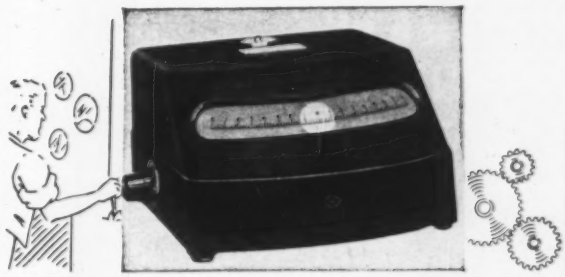

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The Cambridge Spot Galvanometer provides a complete outfit—galvanometer, lamp and scale—in one self-contained plastic case. It is robust, has a stable zero and does not require accurate levelling. The sharply defined spot can easily be read at a distance. The lamp may be operated on A.C. service current or 4-volt battery. Sensitivity in mm. on scale is from 19, 30 and 170 per micro-ampere using coils of 20, 50 and 400 ohms respectively. Scale can be read to 0.2 mm. Send for Bulletin 271.

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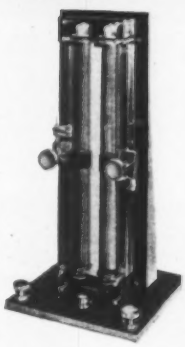

The versatile micromanometer which can be operated at high working pressures. A simple U-tube with vernier readers makes it possible to offer this exclusive combination of features:

- 150 PSIG maximum working pressure.
- ± 0.001 inch sensitivity.
- Water or mercury can be used.
- Forward or reverse use without changing connections.
- Range −9 to +11 inches.

WRITE FOR BULLETIN 155

NATIONAL INSTRUMENT LABORATORIES, INC

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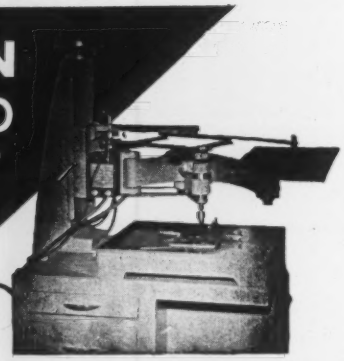
CIRCLE 154 ON READER-SERVICE CARD

GREEN PRINTED CIRCUIT DRILL



A Pneumatic Attachment on The Green Model D2 Pantograph Engraver rapidly drills holes in printed circuits by tracing templates.

- Drill as many as 100 holes per minute. Foot switch actuates air powered operation.
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- Spindle speeds up to 26,000 rpm. Permits use of carbide drills when required.
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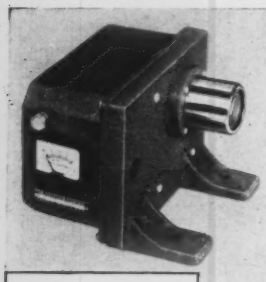

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I&S PEOPLE IN THE NEWS

DAYSTROM, INC. reports that *Thomas Allison*, president of the Industrial Products Group, is attending the thirteen-week Advanced Management Program at Harvard University.

T. ALLISON

H. JACOBSON

LIBRASCOPE DIV. of GENERAL PRECISION has appointed *Hugh Jacobson* manager, system sales at its Burbank Branch.

NBS announces that *Dr. Richard C. Mockler* has been appointed Chief of the Section of Atomic Frequency and Time Standards.

OHMART CORP. announces appointment of *Earl M. Pollock* as vice president.

DYNAMIC CONTROLS CO. announces that *Stewart T. Coffin* has joined the staff as chief engineer.

S. COFFIN

W. JONES

CONAX CORP. announces appointment of *Warren L. Jones* to sales manager, Industrial Products.

GENERAL ATOMIC announces that *John E. Leary* has joined its engineering staff.

John Unertl

John Unertl, 64, died of a heart ailment March 12, 1960 in Pittsburgh. Born in Germany, he had migrated first to Argentina in 1923 and then to Pittsburgh in 1927. In 1934 he established the John Unertl Optical Co. to manufacture precision instruments in the optical field. He was a member of the Pittsburgh Section ISA since 1946.

Mr. Unertl is survived by his widow, Mrs. Anna Hammerl Unertl, his son John, Jr. (partner in the business), two grandchildren, two sisters, and two brothers who are in Germany.

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COMPACT ELECTRIC IMPULSE COUNTERS PRINT AS WELL AS INDICATE

SODECO Print Counters Provide Permanent Records

The new SODECO Print Counters offer all the accuracy and reliability of conventional SODECO counters with the added feature of a printing mechanism to provide a permanent record of the count at any given time.

SINGLE REGISTER:

The compact, single register counters (measuring only 2-7/8" x 5-5/8" x 7-3/16") indicate pulse count to 6-digits and can be supplied with mechanical and electric zero reset. The count can be registered on the paper tape manually or by remote command.

DUPLEX MODELS:

The left-hand register of the duplex model can be specified to indicate and print either date and time or an independent additional 6-digit count.

For complete technical information, write to:

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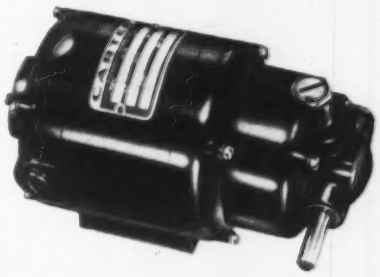
10 single and double reduction models, 10 to 750 r.p.m., 1 to 4 lb. in. torque. Universal, shunt or series motors 12 v. to 220 v. input. Size 6 x $3\frac{5}{16}$ x $3\frac{3}{8}$"

Governor available. Prompt delivery. Liberal O. E. M. discounts.

Write for Prices and Specifications



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ICS NEW LITERATURE

CONTROL SYSTEMS

SUPERVISORY CONTROL SYSTEMS. 12-page Catalog SC3M020 describes systems based on encoding and decoding techniques.—Ascop, a div. of Electro-Mechanical Research, Inc., Box 44, Princeton, N. J.

CIRCLE 304 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS. Wall chart illustrates and specifies 18 types of controlling, recording, computing and telemetering instruments.—Bristol Co., Waterbury 20, Conn.

CIRCLE 305 ON READER-SERVICE CARD

SOAKING PIT CONTROL SYSTEMS. Bulletin MSA-177 contains 11 pages and 4 schematics describing soaking pits and their control systems.—Hagan Chemicals & Controls, Inc., Box 1346, Pittsburgh 30, Pa.

CIRCLE 306 ON READER-SERVICE CARD

CRANE & HOIST CONTROL. 4-page Bulletin H-21 contains application, descriptions, and illustrations of the Hydra-Set, that installs between any crane hook and the load.—Mefco Sales & Service, Inc., 131 North 5th Ave., Arcadia, Calif.

CIRCLE 307 ON READER-SERVICE CARD

COMBUSTION CONTROL UNITS. Three 2-page Bulletins (H-109, H-110, H-111) describe and specify draft regulator, electric power unit, and master regulator, respectively.—Rimcor Products, Inc., Glen Cove, N. Y.

CIRCLE 308 ON READER-SERVICE CARD

VALVE CONTROLS. 32-page Catalog L-550 illustrates and describes several type valve controls, their details and applications.—Philadelphia Gear Corp., Erie Ave. & G St., Phila. 34, Penna.

CIRCLE 309 ON READER-SERVICE CARD

VALVES

BALL VALVES. 4-page brochure "At Your Service" is a pictorial synthesis of the complete Double-Seal ball valve line.—Jamesbury Corp., Worchester, Mass.

CIRCLE 310 ON READER-SERVICE CARD

CONTROL VALVES. 6-page brochure illustrates and specifies low-pressure-drop flow control valves.—Hays Mfg. Co., Automatic Controls Div., 803 West 12th St., Erie, Pa.

CIRCLE 311 ON READER-SERVICE CARD

BALL VALVES. 6-page folder illustrates and describes P-K Paul ball valves.—General Kinetics Corp., 197 South Van Brunt St., Englewood, N. J.

CIRCLE 312 ON READER-SERVICE CARD

AIR VALVES. 2-page Data Sheet V-6 provides design and installation data on air-operated vacuum gate valves.—Vacuum Research Co., 420 Market St., San Francisco 11, Calif.

CIRCLE 313 ON READER-SERVICE CARD

PLUG VALVES. 12-page Catalog 581GP contains pictures, descriptions and specs of non-lubricated plug valves for 1000 to 10,000 psig cold working pressure.—Texstream Corp., 320 Hughes St., Box 9127, Houston 11, Tex.

CIRCLE 314 ON READER-SERVICE CARD

ANGLE VALVES. 2-page Data Unit No. 361 features and specifies the unique No. 74 universal angle valve for liquid level gages or instrument piping.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 315 ON READER-SERVICE CARD

GATE VALVES. 24-page Catalog 1200 describes with illustrations and dimensional drawings pressure sealing gate valves.—W-K-M Div. of ACF Industries, Inc., Box 2117, Houston, Tex.

CIRCLE 316 ON READER-SERVICE CARD

SAUNDERS VALVES. 8-page Bulletin HB-7 illustrates and gives construction details, operating characteristics, and specs of Series HB Saunders valves.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

CIRCLE 317 ON READER-SERVICE CARD

TEMPERATURE

HOT HARDNESS FURNACES. Specification Sheet 824-A contains engineering data on construction and performance of 58-HD vacuum hot hardness testing furnace.—Marshall Products Co., 270 W. Lane Ave., Columbus 2, Ohio.

CIRCLE 318 ON READER-SERVICE CARD

TEMPERATURE PROBE. 2-page Bulletin 8.3 describes, illustrates, and specifies non-cooled high-gas-temperature probe.—Aero Research Inst. Co., Inc., 315 N. Aberdeen St., Chicago 7, Ill.

CIRCLE 319 ON READER-SERVICE CARD

LEVEL, PUMPS

MATERIAL LEVEL INDICATOR. 8-page Bulletin 1-5-C describes automatic control of level of pulverized, fine, crushed, or granular material.—Fuller Co., Catasauqua, Penna.

CIRCLE 320 ON READER-SERVICE CARD

CONTROLLED-VOLUME PUMPS. 4-page Data Sheet D-59-1 explains how controlled volume pumps can solve the problem of metering a softening agent into the distribution lines at pumping stations.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Penna.

CIRCLE 321 ON READER-SERVICE CARD

PROPORTIONING PUMP. 2-page Bulletin 1331.20-1 describes and specifies low-cost, positive-displacement pump for feeding concentrated corrosive chemicals.—B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

CIRCLE 322 ON READER-SERVICE CARD

SWITCHES

PRESSURE SWITCHES. Two 2-page spec sheets describe and specify Types RC-30 and RC-55 absolute air pressure switches.—Newark Controls Co., Bloomfield, N. J.

CIRCLE 356 ON READER-SERVICE CARD

INSTRUMENT SWITCHES. 28-page illustrated catalog describes 30 types of precision instrument switches.—Cinema Engineering Div., Aerovox Corp., 1100 Chestnut St., Burbank, Calif.

CIRCLE 357 ON READER-SERVICE CARD

MISCELLANEOUS

MOTOR CONTROLS. 72-page Catalog GEC-1260D contains information on the complete line of control devices manufactured by the General Purpose Control Dept.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 358 ON READER-SERVICE CARD

NITROGEN DIOXIDE DETECTOR. 2-page Bulletin 0805-4 describes how the Nitrogen dioxide detector provides rapid measurements.—Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh 8, Pa.

CIRCLE 359 ON READER-SERVICE CARD

FACILITIES. 6-page folder contains information on the company, its products, facilities, and staff.—Itemco Inc., 18 Beechwood Ave., Port Washington, N. Y.

CIRCLE 360 ON READER-SERVICE CARD

ELECTROMECHANICAL MECHANICAL COMPONENTS

ELECTROMAGNET. Four spec sheets describe and illustrate Model L-75 lab-type electromagnet and power supply.—Harvey-Wells Electronics, Inc. R. and D. Div. 14 Huron Dr., East Natick Industrial Pk., Natick, Mass.

CIRCLE 361 ON READER-SERVICE CARD

FLEXIBLE STRUTS. 8-page Catalog 204 describes and illustrates "ball-type" flexible struts.—Barco Mfg. Co., 500-530 North Hough St., Barrington, Ill.

CIRCLE 362 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

RESISTOR SELECTOR CHART. 2-page loose-leaf chart, Form Z-44A, simplifies selection of resistors.—Daystrom-Weston Sales Div., 614 Frelinghuysen Ave., Newark 12, N. J.

CIRCLE 363 ON READER-SERVICE CARD

ELECTROMAGNETIC PICKUPS. 4-page Bulletin 2A describes "excitation of magnetic pickups with gears."—Electro Products Labs., Inc., 4501 N. Ravenswood Ave., Chicago 40, Ill.

CIRCLE 364 ON READER-SERVICE CARD

PRESSURE, WEIGHT VACUUM

PRESSURE GAGES & INSTRUMENTS. 4-page Bulletin 3015 features pressure and vacuum gages, indicating pneumatic controllers, and pneumatic transmitters.—U. S. Gauge Div. of American Machine & Metals, Inc., Sellersville, Penna.

CIRCLE 323 ON READER-SERVICE CARD

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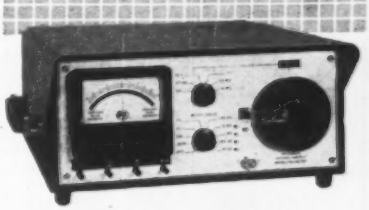

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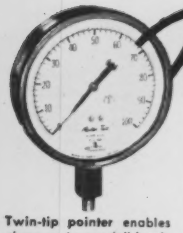

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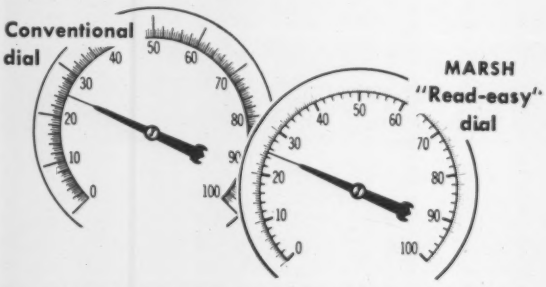

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CIRCLE 165 ON READER-SERVICE CARD

VACUUM GAGES. 6-page Catalog 175 describes the various models of heated thermopile vacuum gages.—Hastings-Raydist, Inc., Hampton, Virginia.

CIRCLE 324 ON READER-SERVICE CARD

INDUSTRIAL WEIGHING. 8-page bulletin contains illustrations and specs of 31 types of crane scales.—Hydroway Scales, Inc., Box 531 Oakridge Station, Royal Oak, Mich.

CIRCLE 325 ON READER-SERVICE CARD

MANOMETERS. 4-page Bulletin 10-17-959 illustrates and specifies absolute and differential manometers.—Ideal-Aerosmith, 3913 Evans Ave., Cheyenne, Wyo.

CIRCLE 326 ON READER-SERVICE CARD

VACUUM EQUIPMENT. 8-page Report No. 3 contains information on vacuum pumps, etc.—Kinney Vacuum Div., New York Air Brake Co., 3529 Washington St., Boston 30, Mass.

CIRCLE 327 ON READER-SERVICE CARD

PRESSURE INSTRUMENTATION. 4-page brochure describes pressure transducers.—Ultradyne, Inc., 2630 San Mateo, N. E., Albuquerque, N. M.

CIRCLE 328 ON READER-SERVICE CARD

WEIGHING EQUIPMENT. Broadside Form 2001e illustrates and describes a wide selection of scales.—Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio.

CIRCLE 329 ON READER-SERVICE CARD

SPEED, COUNT

ELECTRIC TACHOMETER. 2-page bulletin illustrates and describes portable and hand tachometers.—Electro-Mechano Co., 241 East Erie St., Milwaukee, Wis.

CIRCLE 330 ON READER-SERVICE CARD

ELECTRONIC COUNTER. 2-page bulletin describes and specifies Model 37 preset electronic counter.—C&K Components, Inc., 101 Morse St., Newton 58, Mass.

CIRCLE 331 ON READER-SERVICE CARD

OPTICAL

OSCILLOSCOPE PHOTOGRAPHY. 20-page reprint describes applications of the Land process.—Polaroid Corp., 730 Main St., Cambridge 39, Mass.

CIRCLE 332 ON READER-SERVICE CARD

PENTA PRISM BEHAVIOR. 20-page booklet describes the effects of changes in Penta Prism position and alignment in optical tooling techniques.—Engis Equipment Co., Div. of Engineering and Scientific Instrumentation, 431 S. Dearborn St., Chicago 5, Ill.

CIRCLE 333 ON READER-SERVICE CARD

DATA HANDLING

COMPUTING SYSTEM. 6-page brochure S-483 describes the Royal Precision RPC-4000 electronic computing system.—Royal McBee Corp., Data Processing Div., Port Chester, N. Y.

CIRCLE 334 ON READER-SERVICE CARD

PRINT STATION. 8-page brochure illustrates and describes Anelex high-speed printing system.—Anelex Corp., 150 Causeway St., Boston 14, Mass.

CIRCLE 335 ON READER-SERVICE CARD

ELECTROMECHANICAL CONTROLLER 20-page brochure "Teletype 28 Stunt Box," describes built-in control mechanism for Teletype equipment.—Teletype Corp., Dept. SP-9, 4100 Fullerton Ave., Chicago 39, Ill.

CIRCLE 336 ON READER-SERVICE CARD

DIGITAL LOGIC MODULE. 4-page Bulletin TTS-A-6000A describes solid state switching-circuit module.—Tele-Dynamics, Div., of American Bosch Arma Corp., 5000 Parkside Ave., Phila. 31, Penna.

CIRCLE 337 ON READER-SERVICE CARD

DIGITAL LOGIC CIRCUITS. 4-page Bulletin 59-B describes Series 2010 Logix Blocks.—Rese Engineering, Inc., 731 Arch St., Phila 6, Penna.

CIRCLE 338 ON READER-SERVICE CARD

DATA-LOGGERS. 10-page brochure describes the features of Data-Master loggers.—Hanson-Gorrill-Brian, Inc., Glen Cove, N. Y.

CIRCLE 339 ON READER-SERVICE CARD

MAGNETIC TAPE STORAGE. 6-page Bulletin 3209 outlines features of the 205 Datafile auxiliary magnetic tape storage.—ElectroData Div., Burroughs Corp., 460 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 340 ON READER-SERVICE CARD

RECORDERS

BENCH STRIP-CHART RECORDER. 4-page Bulletin SR describes with specs low cost recorder Model SR.—E. H. Sargent & Co., 4647 W. Foster, Chicago 30, Ill.

CIRCLE 341 ON READER-SERVICE CARD

X-Y RECORDER. 2-page Bulletin 794-1 gives data on large-scale (24" x 36") X-Y recorder. Houston Instrument Corp., Box 22234, Houston 27, Texas.

CIRCLE 342 ON READER-SERVICE CARD

TESTING

PUSH-PULL TESTER. 2-page bulletin describes and illustrates a new multi-purpose tester.—Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

CIRCLE 343 ON READER-SERVICE CARD

HYDRAULIC CIRCUIT TESTER. 4-page bulletin "Track Down Hydraulic Troubles" outlines methods for trouble-shooting hydraulic systems.—Schroeder Brothers Corp., Box 72, Nichol Ave., McKees Rocks, Penna.

CIRCLE 344 ON READER-SERVICE CARD

CABLE FAULT LOCATOR. 4-page Bulletin, Form 59-722-1, gives description, specs, and applications of cable fault finder, Model 722.—Smith-Florence Inc., 4228 Twenty-third Ave. West, Seattle 99, Wash.

CIRCLE 345 ON READER-SERVICE CARD

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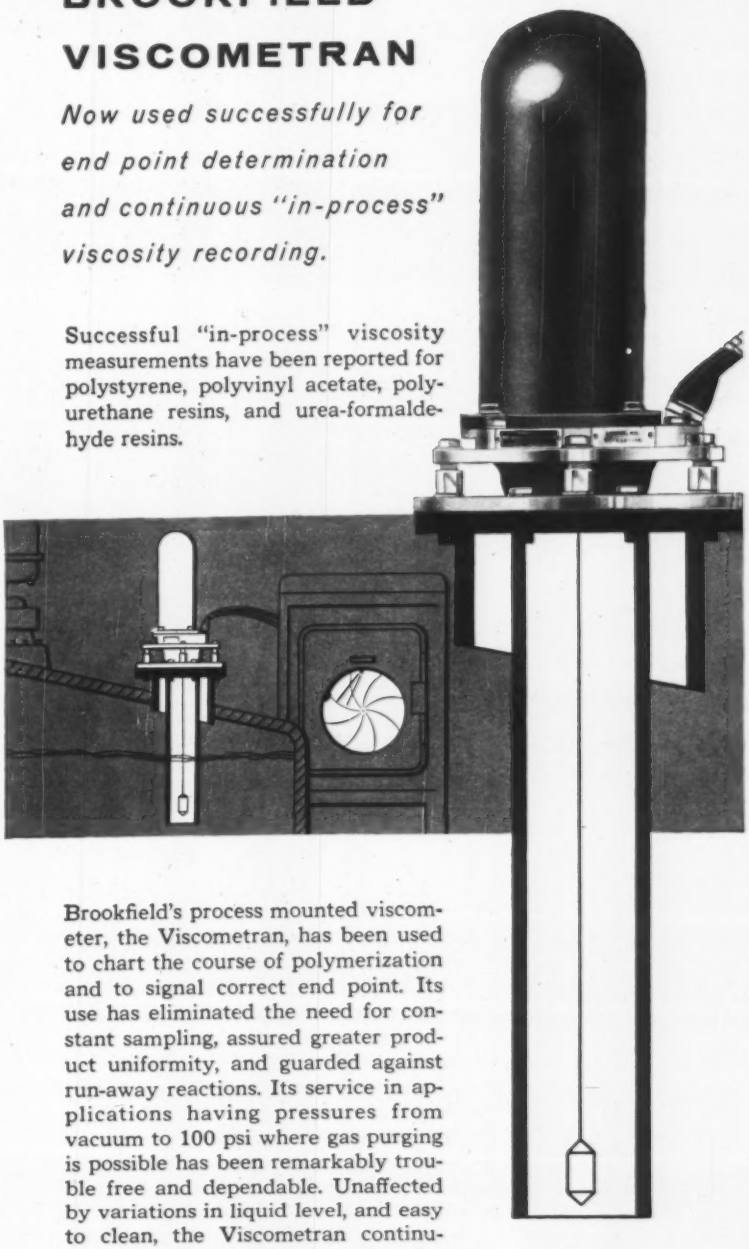

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CIRCLE 166 ON READER-SERVICE CARD

ICS NEW LITERATURE

TESTING MACHINERY. 14-page Bulletin R1-S-59 is a supplement to a previous bulletin on recorder and accessories for use with maker's testing machines.—Riehle Testing Machines, a div. of American Machine and Metals, Inc., East Moline, Ill.

CIRCLE 346 ON READER-SERVICE CARD

TUBING, FITTINGS

SWAGEABLE T/C TUBING. 2-page data sheet describes high-temperature swageable thermocouple tubing.—Saxonburg Ceramics, Inc., Saxonburg, Penna.

CIRCLE 347 ON READER-SERVICE CARD

TUBE FITTINGS. 44-page Catalog 3108 contains technical data, and describes the complete Hi-Seal butt-joint fitting line.—Imperial Brass Mfg. Co., 6300 W. Howard St., Chicago 48, Ill.

CIRCLE 348 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

D-C NULL DETECTOR. 2-page Data Sheet ED7(2) describes the 9834 guarded d-c null detector.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 349 ON READER-SERVICE CARD

PHASE METERS. 2-page condensed catalog and 3 bulletins describe 10 phase instruments.—Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J.

CIRCLE 350 ON READER-SERVICE CARD

ELECTRONIC VOLTMETERS. Folder of 8 data sheets describes panel-mounting electronic voltmeters.—Metronix, Inc., Chesterland, Ohio.

CIRCLE 351 ON READER-SERVICE CARD

MAGNETIC FIELD METER. 8-page folder, From TR-16704, discusses the operation, specs, features, and typical applications of precision magnetic field meter.—Magnaflux Corp., a subs. of General Mills, 7300 West Lawrence Ave., Chicago 3, Ill.

CIRCLE 352 ON READER-SERVICE CARD

R-F BRIDGE. 2-page Bulletin WK-B-601 describes r-f bridge Type B-601.—Wayne Kerr Corp., 1633 Race St., Phila. 3, Pa.

CIRCLE 353 ON READER-SERVICE CARD

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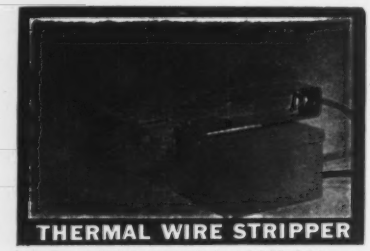

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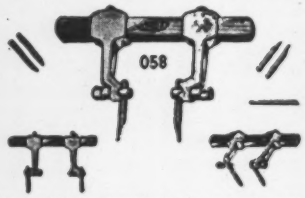

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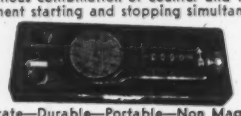

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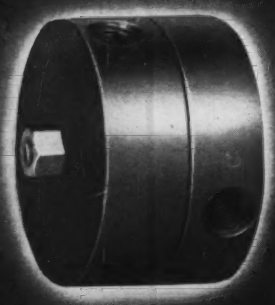

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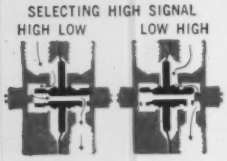

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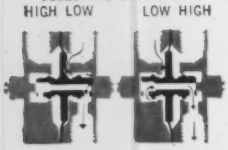

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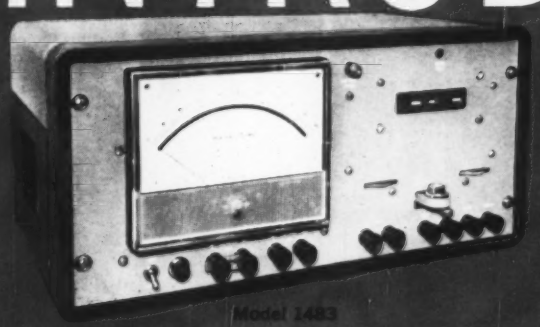

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